SPECIAL EDITION

SCIENTIFIC AMERICAN

WWW.SCIAM.COM

Display until March 28, 2005

Mysteries of the Ancient Ones

- The Lost Indus Cities
- Everyday Life in Egypt
- Death Cults of Malta
- Stone Age Equality
- Gold Masters of Peru

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

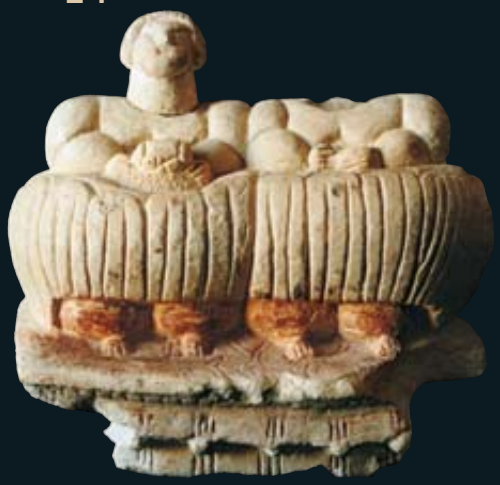
Scientific American Volume 15, Number 1

Contents 2005

Mysteries of the Ancient Ones

24

14



Europe and Asia

4 The Iceman Reconsidered

BY JAMES H. DICKSON, KLAUS OEGGL AND LINDA L. HANDLEY

Where was the Iceman's home, and what was he doing at that high mountain pass where he died? Painstaking research—especially of plant remains found with the body—contradicts many of the initial speculations.

14 The Death Cults of Prehistoric Malta

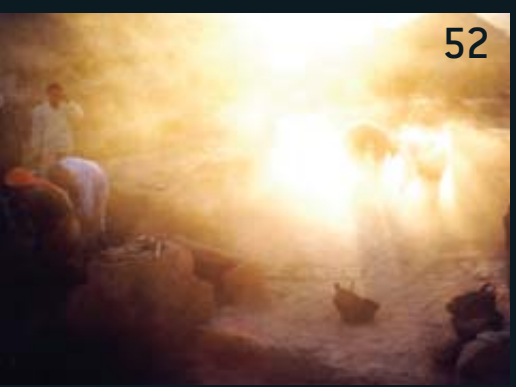
BY CAROLINE MALONE, ANTHONY BONANNO, TANCRED GOUDER, SIMON STODDART AND DAVID TRUMP

New archaeological excavations reveal that as the ancient island societies suffered from environmental decline, they developed an extreme religious preoccupation with life and death.

24 Uncovering the Keys to the Lost Indus Cities

BY JONATHAN MARK KENOYER

Recently excavated artifacts from Pakistan have inspired a reevaluation of one of the great early urban cultures—the enigmatic Indus Valley civilization.



52

Africa and the Middle East

34 Women and Men at Çatalhöyük

BY IAN HODDER

The largest known Neolithic settlement yields clues about the roles played by the sexes in early agricultural societies.

42 Rock Art in Southern Africa

BY ANNE SOLOMON

Paintings and engravings made by ancestors of the San peoples encode the history and culture of a society thousands of years old.

52 Life and Death in Nabada

BY JOACHIM BRETSCHNEIDER

Excavations in northern Syria reveal the metropolis of Nabada, founded 4,500 years ago. Its elaborate administration and culture rivaled those of the fabled cities of southern Mesopotamia.

42

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

60 The Tapestry of Power in a Mesopotamian City
BY ELIZABETH C. STONE AND PAUL ZIMANSKY
Mashkan-shapir was for a brief time one of the most important cities in the world. Its remains challenge traditional notions of power distribution in early urban society.

68 Daily Life in Ancient Egypt
BY ANDREA G. McDOWELL
Workmen and their families lived some 3,000 years ago in the village now known as Deir el-Medina. Written records from the unusually well educated community offer fascinating descriptions of everyday activities.

74 Great Zimbabwe
BY WEBBER NDORO
For centuries, this ancient Shona city stood at the hub of a vast trade network. The site has also been at the center of a bitter debate about African history and heritage.

The Americas

80 Precious Metal Objects of the Middle Sicán
BY IZUMI SHIMADA AND JO ANN GRIFFIN
A Peruvian culture older than that of the Incas made unprecedented use of gold and other metals. Studies of Sicán metalworking techniques offer hints about this mysterious society.

90 Life in the Provinces of the Aztec Empire
BY MICHAEL E. SMITH
The lives of the Aztec common people were far richer and more complex than the official histories would have us believe.

98 Reading the Bones of La Florida
BY CLARK SPENCER LARSEN
New approaches are offering insight into the lives of Native Americans after the Europeans arrived. Their health declined not only because of disease but because of their altered diet and living circumstances.

Cover photograph by Yutaka Yoshii

Scientific American Special (ISSN 1048-0943), Volume 15, Number 1, 2005, published by Scientific American, Inc., 415 Madison Avenue, New York, NY 10017-1111.

Copyright © 2005 by Scientific American, Inc. All rights reserved. No part of this issue may be reproduced by any mechanical, photographic or electronic process, or in the form of a phonographic recording, nor may it be stored in a retrieval system, transmitted or otherwise copied for public or private use without written permission of the publisher.

Canadian BN No. 127387652RT; QST No. Q1015332537. To purchase additional quantities: U.S., $10.95 each; elsewhere, $13.95 each. Send payment to Scientific American, Dept. ANCIENT, 415 Madison Avenue, New York, NY 10017-1111. Inquiries: fax 212-355-0408 telephone 212-451-8890. Printed in U.S.A.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

SCIENTIFIC AMERICAN®
Established 1845

Mysteries of the Ancient Ones is published by the staff of SCIENTIFIC AMERICAN, with project management by:

EDITOR IN CHIEF: John Rennie
EXECUTIVE EDITOR: Mariette DiChristina
ISSUE EDITOR: Larry Katzenstein

ART DIRECTOR: Edward Bell
ISSUE DESIGNER: Lucy Reading-Ikkanda
PHOTOGRAPHY EDITORS: Emily Harrison, Smitha Alampur
PRODUCTION EDITOR: Alysa Cardone

COPY DIRECTOR: Maria-Christina Keller
ASSISTANT COPY CHIEF: Daniel C. Schlenoff
COPY AND RESEARCH: Michael Battaglia, Sara Beardsley, Kenneth Silber

EDITORIAL ADMINISTRATOR: Jacob Lasky
SENIOR SECRETARY: Maya Harty

ASSOCIATE PUBLISHER, PRODUCTION: William Sherman
MANUFACTURING MANAGER: Janet Cermak
ADVERTISING PRODUCTION MANAGER: Carl Cherebin
PREPRESS AND QUALITY MANAGER: Silvia Di Placido
PRODUCTION MANAGER: Christina Hippeli
CUSTOM PUBLISHING MANAGER: Madelyn Keyes-Milch

ASSOCIATE PUBLISHER/VICE PRESIDENT, CIRCULATION: Lorraine Leib Terlecki
CIRCULATION DIRECTOR: Katherine Corvino
FULFILLMENT AND DISTRIBUTION MANAGER: Rosa Davis

VICE PRESIDENT AND PUBLISHER: Bruce Brandfon
WESTERN SALES MANAGER: Debra Silver
SALES DEVELOPMENT MANAGER: David Tirpack
WESTERN SALES DEVELOPMENT MANAGER: Valerie Bantner
SALES REPRESENTATIVES: Stephen Dudley, Hunter Millington, Stan Schmidt

ASSOCIATE PUBLISHER, STRATEGIC PLANNING: Laura Salant
PROMOTION MANAGER: Diane Schube
RESEARCH MANAGER: Aida Dadurian
PROMOTION DESIGN MANAGER: Nancy Mongelli
GENERAL MANAGER: Michael Florek
BUSINESS MANAGER: Marie Maher
MANAGER, ADVERTISING ACCOUNTING AND COORDINATION: Constance Holmes

DIRECTOR, SPECIAL PROJECTS: Barth David Schwartz

MANAGING DIRECTOR, ONLINE: Mina C. Lux
OPERATIONS MANAGER, ONLINE: Vincent Ma
SALES REPRESENTATIVE, ONLINE: Gary Bronson

DIRECTOR, ANCILLARY PRODUCTS: Diane McGarvey
PERMISSIONS MANAGER: Linda Hertz
MANAGER OF CUSTOM PUBLISHING: Jeremy A. Abbate

CHAIRMAN EMERITUS: John J. Hanley
CHAIRMAN: John Sargent
PRESIDENT AND CHIEF EXECUTIVE OFFICER: Gretchen G. Teichgraeber
VICE PRESIDENT AND MANAGING DIRECTOR, INTERNATIONAL: Dean Sanderson
VICE PRESIDENT: Frances Newburg

letter from the editor

Lost Ways of Life

RANDY OLSON *Aurora Photos*; DEPARTMENT OF ARCHAEOLOGY AND MUSEUMS, GOVERNMENT OF PAKISTAN

ENIGMATIC ancient from the Indus.

HE PEERS OUT AT ME a bit disdainfully, I think, with his diadem and brocaded fabric slung regally over one shoulder. But I don't take it personally. After all, the so-called priest-king has regarded all comers that way since he emerged from soapstone under the careful ministrations of an Indus Valley sculptor some 4,000 years ago. His enigmatic gaze—by turns seemingly guarded, pensive, smug or maybe just sleepy—is emblematic of the challenges for archaeologists who are trying to interpret the physical signs of everyday life left behind by ancient peoples. What role did the priest-king's ilk play? What was the artist thinking when he made the figure? What was workaday existence like?

Aspects of the priest-king's society, featured in "Uncovering the Keys to the Lost Indus Cities," on page 24, remain mysterious, because we have yet to decipher its writing. Lacking such direct communiqués from ancient peoples, archaeologists turn to other clues—their structures, their artwork, their tools, even their very bones. Examining such relics, scientists attempt to fit the pieces into a comprehensive cultural picture. As fellow members of humanity, the ancient ones must have been very much like us in many ways. But the latest excavations are uncovering some surprising differences as well. Consider the denizens of Çatalhöyük, in central Turkey, 9,000 years ago. Oddly, they walked atop their city and entered their houses from above. They had no sidewalks, no front doors. Yet they had a remarkably modern knack for sharing tasks between the sexes. Perhaps surprisingly, in Egypt circa 1500 B.C.E., even stonecutters had the chance to learn to read and write in a community that greatly valued literacy [see "Daily Life in Ancient Egypt," on page 68]. Not all the civilizations' tales end well, of course. One case is the prehistoric people of Malta, near Sicily. In the face of local environmental decline, the Maltese developed a consuming obsession with death, which is all the more poignant because it may have led to the culture's demise. To find out why, see "The Death Cults of Prehistoric Malta," which begins on page 14.

These civilizations, among the others featured in this special edition of *Scientific American*, demonstrate an impressive power to puzzle and intrigue us across the span of time. In the pages that follow, we invite you to contemplate our shared human heritage, in all its glorious—and inglorious—forms.

Mariette DiChristina
Executive Editor
Scientific American
editors@sciam.com

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

The Alps

The Iceman Reconsidered

By James H. Dickson, Klaus Oeggl and Linda L. Handley

On a clear day in September 1991 a couple hiking along a high ridge in the Alps came upon a corpse melting out of the ice. When they returned to the mountain hut where they were staying, they alerted the authorities, who assumed the body was one of the missing climbers lost every year in the crevasses that crisscross the glaciers of the region. But after the remains were delivered to nearby Innsbruck, Austria, Konrad Spindler, an archaeologist from the university there, ascertained that the corpse was prehistoric. The victim, a male, had died several thousand years ago. Spindler and other scientists deduced that his body and belongings had been preserved in the ice until a fall of dust from the Sahara and an unusually warm spell combined to melt the ice, exposing the man's head, back and shoulders.

No well-preserved bodies had ever been found in Europe from this period: the Neolithic, or New Stone Age. The Iceman is much older than the Iron Age men from the Danish peat bogs and older even than the Egyptian royal mummies. Almost as astounding was the presence of a complete set of clothes and a variety of gear.

In the ensuing excitement over the discovery, the press and researchers offered many speculations about the ancient man. Spindler hypothesized an elaborate disaster theory. He proposed that the man had fled to safety in the mountains after being injured in a fight at his home village. It was autumn, Spindler went on, and the man was a shepherd who sought refuge in the high pastures where he took his herds in summer. Hurt and in a state of exhaustion, he fell asleep and died on the boulder on which he was found five millennia later. The beautiful preservation of the body, according to this account, was the result of a fall of snow that protected the corpse from scavengers, followed by rapid freeze-drying.

LANDESGENDARMERIEKOMMANDO FÜR TIROL/AUSTRIA

THE ICEMAN was discovered in a rocky hollow high in the Alps, in the zone of perennial snow and ice. Pressure from the overlying ice had removed a piece of the scalp. His corpse lay draped over a boulder. Contrary to earlier assumptions, evidence indicates the body had floated into that position during previous thaws.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Where was the Iceman's home, and what was he doing at the high mountain pass where he died? Painstaking research—especially of plant remains found with the body—contradicts many of the initial speculations

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Ötzi had been WARMLY DRESSED IN LEGGINGS, loincloth and jacket made of the hide of deer and goat, and a cape made of grass and bast.

Because the uniqueness of the discovery had not been immediately evident, the corpse was torn from the ice in a way that destroyed much archaeological information and damaged the body itself. A more thorough archaeological excavation of the site took place in the summer of 1992 and produced much valuable evidence, including an abundance of organic material (seeds, leaves, wood, mosses). This material added greatly to the plant remains, especially mosses, already washed from the clothes during the conservation process. Now, after a decade of labor-intensive research by us and other scientists on these plant remains and on samples taken from the Iceman's intestines, some hard facts are revising those first, sketchily formed impressions and replacing them with a more substantiated story.

Who Was He?

THE HIKERS HAD DISCOVERED the body at 3,210 meters above sea level in the Ötztal Alps, which led to the popular humanizing nickname Ötzi. A mere 92 meters south of the Austrian-Italian border, the shallow, rocky hollow that sheltered the body is near the pass called Hauslabjoch between Italy's Schnalstal (Val Senales in Italian) and the Ventertal in Austria [*see map on opposite page*]. Ötzi lay in an awkward position, draped prone over a boulder, his left arm sticking out to the right, and his right hand trapped under a large stone. His gear and clothing, also frozen or partially frozen in the ice, were scattered around him, some items as far as several meters away. Radiocarbon dates from three different laboratories made both on plant remains found with the body and on samples of Ötzi's tissues and gear all confirm that he lived about 5,300 years ago.

Certain other features of Ötzi were relatively easy to discover as well. At 159 centimeters (5′ 2.5″), he was a small man, as many men in the Schnalstal vicinity are today. Bone studies show he was 46 years old, an advanced age for people of his time. DNA analysis indicates his origin in central-northern Europe, which may seem obvious, but it differentiates him from Mediterranean people, whose lands lie not too far distant to the south.

In an unusual congenital anomaly, his 12th ribs are missing. His fifth to ninth left ribs had been broken and had healed in his lifetime. Numerous bone fractures and thoracic deformity are attributed by William A. Murphy, Jr., of the M. D. Anderson Cancer Center at the University of Texas to glacial action and the rough recovery of the corpse. That these breakages occurred after death is among the considerable evidence that casts doubt on the early disaster theory. So does the finding that an area of missing scalp was caused by pressure, not by a blow or decay.

Holding aside the unanswered questions concerning Ötzi's death and whether it was violent or not, several sound reasons suggest that he had not been in the best of health when he died. Although most of his epidermis (the outer layer of the skin), hair and fingernails are gone, probably having decayed as a result of exposure to water during occasional thaws, his remains still offer something of a health record for modern investigators. Examination of the only one of his fingernails to have been found revealed three Beau's lines, which develop when the nails stop growing and then start again. These lines show that he had been very ill three times in the last six months of his life and that the final episode, about two months before his death, was the most serious and lasted at least two weeks. Horst Aspöck of the University of Vienna found that he had an infestation of the intestinal parasite whipworm, which can cause debilitating diarrhea and even lead to dysentery, although we do not know how bad his infestation was.

Moreover, many simple, charcoal-dust tattoos are visible on the layer of skin under the missing epidermis. These marks were certainly not decorative and were probably therapeutic. Several are on or close to Chinese acupuncture points and at places where he could have suffered from arthritis—the lower spine, right knee and ankle. This coincidence has led to claims of treatment by acupuncture. Yet, according to Peter Vanezis, now at the Forensic Science Service in London, and Franco Tagliaro of the University of Verona, x-rays show little if any sign of arthritis.

Overview/*A New Look at an Ancient Man*

The most current research indicates that the Iceman:

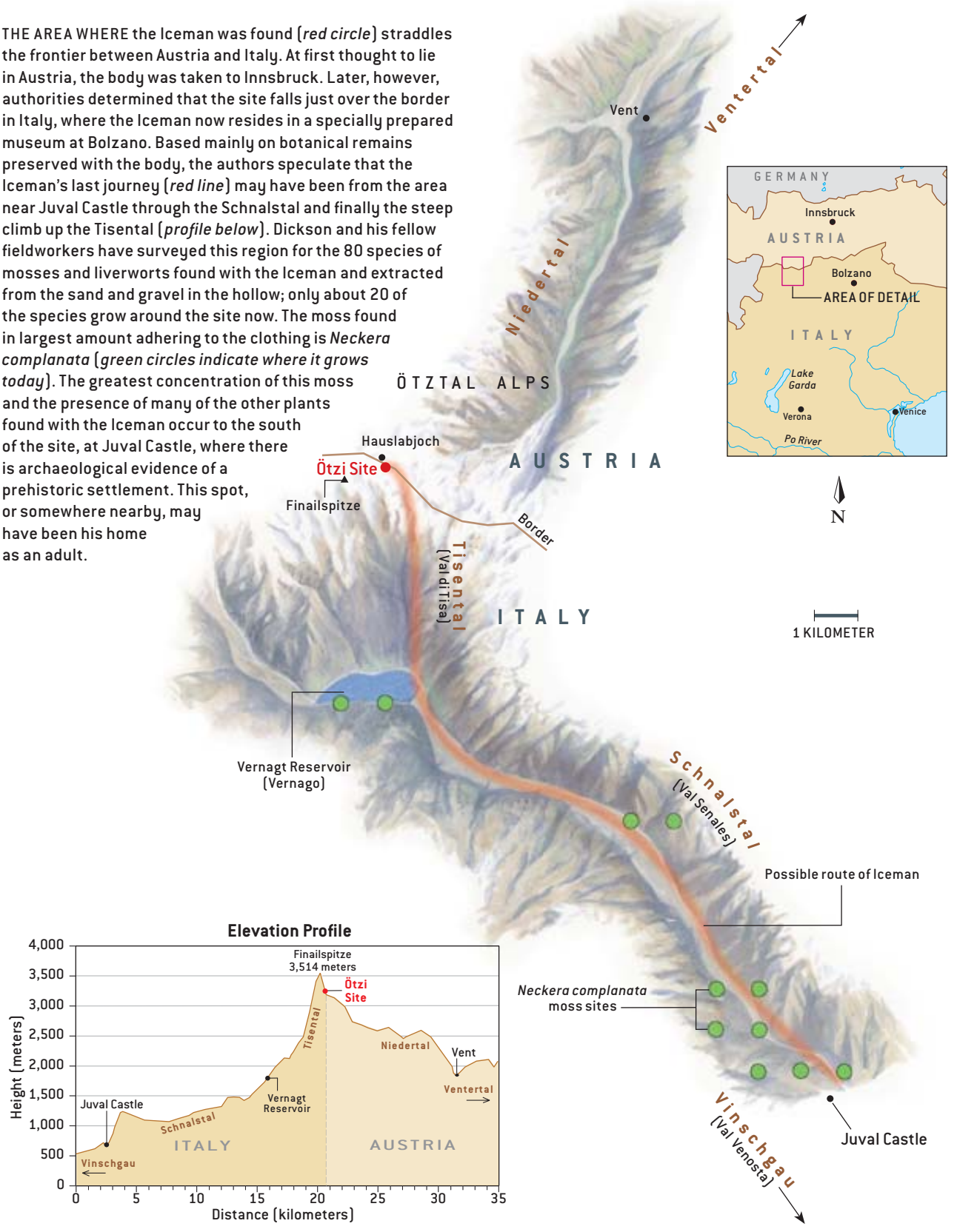
- Lived as a child near Brixen in the Eisack Valley, north of Bolzano, and as an adult in Vinschgau (the Etsch and Schnals valleys).
- Ate a varied diet of primitive wheat, other plants, and meat of alpine ibex and red deer.
- Was 46 years old and had not been in the best of health.
- Died in spring, not in autumn as previously thought.
- Probably died soon after being shot in the back by an arrow.
- Did not expire on the boulder where he was found, as was believed, but floated into position there during occasional thaws.

SOUTH TYROL MUSEUM OF ARCHAEOLOGY, ITALY (www.iceman.it)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

The Route the Iceman May Have Taken

THE AREA WHERE the Iceman was found (*red circle*) straddles the frontier between Austria and Italy. At first thought to lie in Austria, the body was taken to Innsbruck. Later, however, authorities determined that the site falls just over the border in Italy, where the Iceman now resides in a specially prepared museum at Bolzano. Based mainly on botanical remains preserved with the body, the authors speculate that the Iceman's last journey (*red line*) may have been from the area near Juval Castle through the Schnalstal and finally the steep climb up the Tisental (*profile below*). Dickson and his fellow fieldworkers have surveyed this region for the 80 species of mosses and liverworts found with the Iceman and extracted from the sand and gravel in the hollow; only about 20 of the species grow around the site now. The moss found in largest amount adhering to the clothing is *Neckera complanata* (*green circles indicate where it grows today*). The greatest concentration of this moss and the presence of many of the other plants found with the Iceman occur to the south of the site, at Juval Castle, where there is archaeological evidence of a prehistoric settlement. This spot, or somewhere nearby, may have been his home as an adult.



ROB WOOD *Wood Ronsaville Harlin, Inc. (topographic map);* MICHAEL SHAND *University of Glasgow (elevation profile)*

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

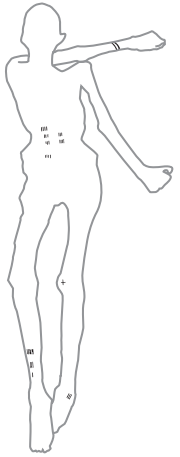
What the Iceman and His Belongings Tell Us

Ötzi was small, standing only 159 centimeters (5′ 2.5″). Desiccation after he died shriveled the body both externally and internally. Ice pressure deformed his upper lip, nose and ears.

He was not bald in life, and he probably had a beard. The epidermis has come off, and all the hair and nails have fallen out. Some of his hair, up to nine centimeters long, was found. Analysis of the hair indicates that he ate a mixed diet of plants and animals.

The isotopic composition of the tooth enamel suggests that he grew up near Brixen in the Eisack Valley, north of Bolzano, but as an adult he migrated to the area of the Etsch and Schnals valleys.

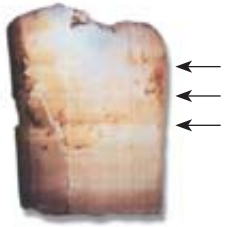
The cap was sewn of brown bearskin.

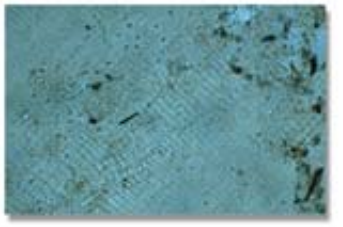


Inconspicuous tattoos, most visible on the back of the body, were simple lines and crosses that may have been intended as therapy.

The handle of the dagger is ash wood; the flint tip may have been broken in antiquity or during the excavation.

Natural processes after death caused the fingers to clench. One fingernail (*below*) was recovered; the lines (*arrows*) reveal that he had been very ill three times in the months before he died.



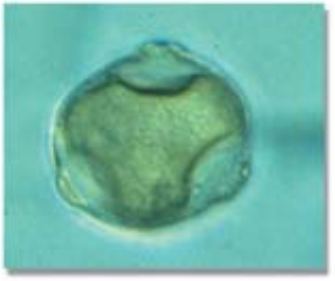


A primitive wheat called einkorn has been identified in his gut, ground so minutely that it may well have been used to make bread. Tiny charcoal particles (*fuzzy, dark shapes, above*) suggest that the bread had been baked on an open fire.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

SOUTH TYROL MUSEUM OF ARCHAEOLOGY, ITALY (www.iceman.it) (*Iceman, ax, bearskin cap*); CHRISTIN BEECK, TAKEN FROM "DIE GLETSCHERMUMIE VOM ENDE DER STEINZEIT AUS DEN ÖTZTALER ALPEN VORBERICHT," RÖMISCH-GERMANISCHES ZENTRALMUSEUM, MAINZ (RGZM) (*shoes, pouch, dagger*); TAKEN FROM "DIE GLETSCHERMUMIE," RGZM (*Iceman outline*); TAKEN FROM "THE MAN IN THE ICE," VOL. 2, BY K. SPINDLER ET AL. (HRSG), DER MANN IM EIS: NEUE FUNDE UND ERGEBNISSE (SPRINGER, VIENNA-NEW YORK, 1995) (*fingernail*); KLAUS OEGGL (*pollen grain, einkorn*); JAMES H. DICKSON (*hop hornbeam tree, moss, leafy stem*)

Contents of the gut confirm that his diet was omnivorous and disclose details of his last meals (red deer, wild goat, plants and ground grains), his environment, his domicile and even his last journey.



In the gut samples, pollen grains (*left*) of the hop hornbeam tree (*below*) indicate that the Iceman died in late spring, when this small tree blooms.

The oldest intact ax ever found, it has a copper head secured to the yew handle by birch glue and bound with strips of hide.

The shoes were carefully stitched from hide and insulated with grass but were in a poorly preserved state, perhaps partly as result of wear and tear during the Iceman's journey.

Leaves of the moss *Neckera complanata,* also in the gut samples, suggest that he had wrapped his food in the moss. At top is the moss growing on a shady rock; below is one leafy stem washed from the clothes.

Radiocarbon dates of body tissues and gear (as well as plants) agree that he lived 5,300 years ago.

A pouch that probably fastened around his waist, although it was no longer in place, contained a fire-making kit, including true tinder fungus (*lower left*) and small flints (*middle*). A flint-sharpening tool is at the lower right.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

On hide thongs, he carried two pierced pieces of BIRCH BRACKET FUNGUS, known to contain pharmacologically active compounds.

The little toe of his left foot reveals evidence of frostbite. Ötzi's teeth are very worn, a reflection of his age and diet. Remains of two human fleas were found in his clothes. No lice were seen, but because his epidermis had been shed, any lice may have been lost.

What Was His Gear Like?

TURNING TO ÖTZI'S clothing and gear, scientists have learned not only about Ötzi himself but about the community in which he lived. The items are a testament to how intimately his people knew the rocks, fungi, plants and animals in their immediate surroundings. And we can see that they also knew how to obtain resources from farther afield, such as flint and copper ore. This knowledge ensured that Ötzi was extremely well equipped, each object fashioned from the material best suited to its purpose.

He had been warmly dressed in three layers of clothing—leggings, loincloth and jacket made of the hide of deer and goat, and a cape made of grass and bast, the long, tough fibers from the bark of the linden tree. His hat was bearskin, and his shoes, which were insulated with grass, had bearskin soles and goatskin uppers.

He had carried a copper ax and a dagger of flint from near Lake Garda, about 150 kilometers to the south. The handle of the dagger was ash wood, a material still used for handles today because it does not splinter easily. His unfinished longbow was carved from yew, the best wood for such a purpose because of its great tensile strength. The famous English longbows used to defeat the French at Agincourt some 4,000 years later were made of yew. A hide quiver contained 14 arrows, only two of which had feathers and flint arrowheads attached, but these two were broken. Thirteen of the arrow shafts were made of wayfaring tree, which produces long, straight, rigid stems of suitable diameter; one was partly of wayfaring tree and partly of dogwood.

A belted pouch contained a tinder kit, which held a bracket fungus that grows on trees, known as the true tinder fungus, and iron pyrites and flints for making sparks. A small tool for sharpening the flints was also found with the body. On hide thongs, Ötzi carried two pierced pieces of birch bracket fungus; it is known to contain pharmacologically active compounds (triterpens) and so may have been used medicinally. There were also the fragments of a net, the frame of a backpack, and two containers made of birch bark; one held both charcoal and leaves of Norway maple—perhaps it originally transported embers wrapped in the leaves.

Where Was He From?

IN THIS PART OF THE ALPS, the valleys run north and south between towering ranges of mountains. Thus, the question of Ötzi's homeland resolves itself into north versus south rather than east versus west. The botanical evidence points to the south. A Neolithic site has been discovered at Juval, a medieval castle at the southern end of the Schnalstal, more than two thousand meters lower but only 15 kilometers from the hollow as the crow flies. Archaeologists have not excavated the site in modern times, and there has been no radiocarbon dating, but Juval is the nearest place to the hollow where a number of the flowering plants and mosses associated with Ötzi now grow. We have no reason to suppose that they did not grow there in prehistoric times, and so perhaps that is the very place where Ötzi lived.

When his clothes were conserved, the washing revealed many plant fragments, including a mass of the large woodland moss *Neckera complanata*. This moss and others he had carried grow to the north and to the south of where he was found, but the southern sources are much closer. *N. complanata* grows in some abundance near Juval. Wolfgang Hofbauer of the Fraunhofer Institute for Building Physics in Valley, Germany, has discovered that this moss grows, in more moderate amounts, at Vernagt (Vernago), just 1,450 meters lower than the site and only five kilometers away. And most recently, Alexandra Schmidl of the University of Innsbruck Institute of Botany discovered small leaf fragments of the moss *Anomodon viticulosus* in samples taken from the colon. This woodland moss grows with *N. complanata* in lowermost Schnalstal.

If Juval was not his home, signs of Neolithic occupation at other locations in the immediately adjacent Vinschgau (Val Venosta), the valley of the river Etsch (Adige), offer other possibilities. In contrast, to the north, the nearest known Stone Age settlements are many tens of kilometers away, and we are not aware of any Neolithic settlements in the Ventertal or elsewhere in the Ötztal. If Ötzi's

THE AUTHORS

JIM DICKSON, KLAUS OEGGL and *LINDA HANDLEY* share an interest in the plants that the Tyrolean Iceman may have used in his daily life. Dickson, professor of archaeobotany and plant systematics at the University of Glasgow, is recipient of the Neill Medal of the Royal Society of Edinburgh. He has written more than 150 papers and five books, including *Plants and People in Ancient Scotland* (Tempus Publishing, 2000), which he co-authored with his late wife, Camilla. Oeggl is professor of botany at the University of Innsbruck in Austria. He is an expert in archaeobotany and co-editor of the book *The Iceman and His Natural Environment* (Springer-Verlag, 2000). Handley, an ecophysiologist at the Scottish Crop Research Institute in Invergowrie, near Dundee, specializes in the study of stable isotopes of carbon and nitrogen in plants and soils.

CHRISTIN BEECK, TAKEN FROM "DIE GLETSCHERMUMIE," RGZM

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

home was indeed in lowermost Schnalstal or in Vinschgau, then his community lived in a region of mild, short, largely snow-free winters, especially so if the climate was then slightly warmer.

Investigations by Wolfgang Müller of the Australian National University in Canberra of the isotopic composition of the Iceman's tooth enamel, bones and intestine and of soils and water of the region indicate that he had likely grown up in one area, near Brixen in the Eisack Valley, north of Bolzano, and in later life migrated to Vinschgau in the Etsch and Schnals valleys.

What Did He Eat?

THE ONGOING STUDIES of the plant remains in samples taken from the digestive tract provide direct evidence of some of Ötzi's last meals. One of us (Oeggl) has detected bran of the primitive wheat called einkorn, so fine that it may well have been ground into flour for baking bread rather than having been made into a gruel. Microscopic debris of as yet unidentified types shows that he had eaten other plants as well. And in their DNA studies of food residues in the intestines, Franco Rollo and his team at the University of Camerino in Italy recognized both red deer and alpine ibex (wild goat). Splinters of ibex neck bones were also discovered close to Ötzi's body. A solitary but whole sloe lay near the corpse as well. Sloes are small, bitter, plumlike fruit, and Ötzi may have been carrying dried sloes as provisions.

Several types of mosses were recovered from Ötzi's digestive tract; similarly, ongoing work by one of us (Dickson) has identified at least six different mosses from the intestines of Kwäday Dän Ts'ìnchí, the first ancient glacier body from the Americas. There is virtually no evidence that humans have ever eaten mosses, certainly not as a staple of their diet. In both cases, these minute fragments probably were accidentally ingested. Five thousand and more years ago no materials were manufactured for wrapping, packing, stuffing or wiping. Mosses were highly convenient for such purposes, as many archaeological discoveries across Europe have revealed: various mosses in Viking and medieval cesspits were clearly used as toilet paper. Had Ötzi's provisions been wrapped in moss, that would neatly explain, as an accidental ingestion, the several leaves and leaf fragments of *N. complanata* recovered from the samples taken from the gut.

Analyzing archaeological remains of bone and hair for their abundances of the stable isotopes of carbon and nitrogen (carbon 13 and nitrogen 15) can provide information about a person's diet. Nitrogen 15 can reveal the extent to which the individual relied on animal or plant protein. Carbon 13 can indicate the type of food plant the person ate and whether seafood or terrestrial carbon was an important part of the diet.

The isotopic data agree with the other evidence that Ötzi ate a mixed diet of plants and animals. He obtained about

ROCK-STREWN, icy site where the Iceman was found has been marked by a commemorative monument. The three men are standing on the very spot where the body lay. Typically, the snow and ice did not melt enough in the summer of 2000, when the photograph was taken, to reveal the boulders and sandy gravel on the bottom of the hollow.

JUVAL CASTLE, in lowermost Schnalstal, is the place nearest to the site where many of the low-altitude plants preserved with the Iceman grow today.

JAMES H. DICKSON

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

30 percent of his dietary nitrogen from animal protein and the rest from plants. This value is consistent with those found in hunter-gatherer tribes living today. The data also indicate that seafood was probably not a component of his diet, a finding that makes sense because of the great distance to the sea.

What Was He Doing There?

TO THIS DAY, in what may be an ancient custom, shepherds take their flocks from the Schnalstal up to high pastures in the Ötztal in June and bring them down again in September. The body was found near one of the traditional routes, which is why early theories held that he was a shepherd. Nothing about his clothing or equipment, however, proves that he had done such work. No wool was on or around his person, no dead collie by his feet, no crook in his hand. Some support for the shepherd hypothesis comes from the grass and bast cape, which has modern parallels in garments worn by shepherds in the Balkans, but that alone is not conclusive; for all we know, it was standard dress for travelers at that time.

Additional doubts about the shepherd theory come from a recent investigation of more than 100 dung pellets from the find spot by Oeggl and his colleagues. Pollen and macrofossil analyses can distinguish between dung derived from livestock (such as from a sheep or goat) or from game (an ibex or a chamois). The pellets were collected during the archaeological excavation in 1992, and multiple carbon 14 dates give ages of 5400 to 2000 B.C.E. The analyses have shown that all the droppings derive from wild animals grazing in high-altitudinal habitats. This finding weakens the argument that seasonal migration of livestock was practiced in Neolithic times in that area and casts serious doubt on the explanation of Ötzi having been a shepherd.

Analysis of the few strands of Ötzi's hair that survived reveals very high values of both arsenic and copper. The published explanation (also given independently on television) was that he had taken part in the smelting of copper. But Geoffrey Grime of the University of Surrey in England now considers that these exceptional levels may have resulted from the action of metal-fixing bacteria after Ötzi died and that the copper was on, not in, the hair. Further support for the possibility of copper having attached itself to the hair after death comes from the presence of the moss *Mielichhoferia elongata,* called copper moss, which spreads preferentially on copper-bearing rocks. It has been found growing at the site by one of us (Dickson) and, independently, by Ronald D. Porley of the U.K. government conservation agency English Nature.

Another hypothesis is that Ötzi was a hunter of alpine ibex; the longbow and quiver of arrows may support this notion. If, however, he had been actively engaged in hunting at the time of his death, why is the bow unfinished and unstrung and all but two of the arrows without heads and feathers, and those two broken?

Other early ideas about Ötzi are that he was an outlaw, a trader of flint, a shaman or a warrior. None of these has any solid basis, unless the pieces of bracket fungus he was carrying had medicinal or spiritual use for a shaman.

How Did He Die?

IN JULY 2001 Paul Gostner and Eduard Egarter Vigl of the Regional Hospital of Bolzano in Italy announced that x-rays had revealed an arrowhead in Ötzi's back under the left shoulder. If the arrowhead cut an artery, he died within a few hours; if not, then days may have elapsed before his demise. What needs to be done to settle this question is for the arrowhead to be removed so skillfully that precisely what damage it did can be revealed.

Recently, during a careful reexamination of the corpse, Egarter-Vigl and Andreas G. Nerlich of the Ludwig Maximilian University in Munich detected a 3.7-centimeter-long, deep stab wound in Ötzi's right palm extending to the lateral back. Histological analysis revealed that the injury happened between three and eight days before his death. At present, it is unknown if the two wounds resulted from the same attack, but if so, then it means that Ötzi survived being hit by the arrow for at least a few days.

In 2003 a claim that Ötzi had been involved in battle because of the presence of other people's blood on his clothing was made by Tom Loy of the University of Queensland. So far it has

THE ICEMAN was well attired in three layers of clothing fashioned from skins, grass and bark fibers. These reconstructions were made by the archaeologists in the Roman-Germanic Museum in Mainz, Germany, where all of the Iceman's clothing and gear were restored.

JULIA RIBBECK, TAKEN FROM "DIE GLETSCHERMUMIE," RGZM

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

THE ICEMAN now lies in a specially built chamber at the South Tyrol Museum of Archaeology in Bolzano, Italy, that keeps him at –6 degrees Celsius and roughly 99 percent humidity.

SOUTH TYROL MUSEUM OF ARCHAEOLOGY, ITALY (www.iceman.it)

been promulgated only at a press conference and on television. Until this work is reputably published, it cannot be assessed.

At What Time of Year?

INITIAL REPORTS PLACED the season of death in autumn. The presence of the sloe, which ripens in late summer, near the body and small pieces of grain in Ötzi's clothing, presumed to have lodged there during harvest threshing, formed the basis for these reports. But strong botanical evidence now indicates that Ötzi died in late spring or early summer. Studies by Oeggl of a tiny sample of food residue from Ötzi's colon have revealed the presence of the pollen of a small tree called hop hornbeam. Strikingly, much of that pollen has retained its cellular contents, which normally decay swiftly. This means that Ötzi might have ingested airborne pollen or drunk water containing freshly shed pollen shortly before he died. The hop hornbeam, which grows up to about 1,200 meters above sea level in the Schnalstal, flowers only in late spring and early summer.

As for the sloe found near his body, if Ötzi had been carrying sloes dried like prunes, the drying could have taken place some time before his journey. Small bits of grain also keep indefinitely, and a few scraps could have been carried inadvertently in his clothes for a long period.

What We Know

MORE THAN 10 YEARS after the discovery of the oldest, best-preserved human body, interpretations about who he was and how he came to rest in a rocky hollow high in the Alps have changed greatly. Just as important, we see that much careful research still needs to be done. The studies of the plant remains—the pollen, seeds, mosses and fungi found both inside and outside the body—have already disclosed a surprising number of Ötzi's secrets. We are aware of his omnivorous diet, his intimate knowledge of his surroundings, his southern domicile, his age and state of health, the season of his death, and something of his environment. Perhaps one of the most surprising reinterpretations is that Ötzi did not die on the boulder on which he was found. Rather he had floated there during one of the temporary thaws known to have occurred over the past 5,000 years. The positioning of the body, with the left arm stuck out awkwardly to the right and the right hand trapped under a stone, and the missing epidermis both suggest this conclusion. So does the fact that some of his belongings lay several meters distant, as if they had floated away from the body.

But we do not know and may never know what reason Ötzi had for being at a great altitude in the Alps. And we may never understand exactly how he died. An autopsy would be too destructive. In the absence of this kind of proof, we cannot completely exclude the possibility that perhaps Ötzi died somewhere else and was carried at some point to the hollow where the hikers found him 5,000 years later.

Because of near-instantaneous preservation by freezing, bodies that melt from glaciers, such as Ötzi and Kwäday Dän Ts'ìnchí, are outstanding sources of scientific and cultural information about humankind from periods long ago.

Such corpses show us in the most dramatic fashion how well our ancestors knew their environments. They can tell us much about the precise moments of death in ways that other archaeological remains, such as burials, cannot, certainly not in such comprehensive ways: how the people looked, how they dressed, how they were equipped, how healthy they were, what they had just eaten, as well as their long-term diets and, by detailed analyses of gut contents, where they had traveled during their last few days.

With glaciers the world over in retreat, more ancient bodies may well be discovered, but few, if any, can be expected to be as old and intact as Ötzi. Nevertheless, all such corpses, even if only centuries rather than millennia old, should be investigated scientifically, especially if ingested food still remains in their alimentary tracts. SA

MORE TO EXPLORE

The Omnivorous Tyrolean Iceman: Colon Contents (Meat, Cereals, Pollen, Moss and Whipworm) and Stable Isotope Analyses. James H. Dickson et al. in *Philosophical Transactions of the Royal Society of London, Series B,* Vol. 355, pages 1843–1849; December 29, 2000.

INSIGHT: Report of Radiological-Forensic Findings on the Iceman. Paul Gostner and Eduard Egarter Vigl in *Journal of Archaeological Science,* Vol. 29, No. 3, pages 323–326; March 2002.

Ötzi's Last Meals: DNA Analysis of the Intestinal Content of the Neolithic Glacier Mummy from the Alps. Franco Rollo et al. in *Proceedings of the National Academy of Sciences USA,* Vol. 99, No. 20, pages 12594–12599; October 1, 2002.

The Iceman: Discovery and Imaging. W. A. Murphy et al. in *Radiology,* Vol. 226, No. 3, pages 614–629; March 2003.

Origin and Migration of the Alpine Iceman. Wolfgang Müller et al. in *Science,* Vol. 302, pages 862–866; October 31, 2003.

Kwäday Dän Ts'ìnchí, the First Ancient Body of a Man from a North American Glacier: Reconstructing His Last Days by Intestinal and Biomolecular Analyses. J. H. Dickson et al. in *Holocene,* Vol. 14, No. 4, pages 481–486; 2004.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Malta

The Death Cults of Prehistoric Malta

New archaeological excavations reveal that as the ancient island societies suffered from environmental decline, they developed an extreme religious preoccupation with life and death

By Caroline Malone, Anthony Bonanno, Tancred Gouder, Simon Stoddart and David Trump

The Mediterranean region is a fine laboratory for the scientific study of early religions because so many emerged there. Everyone has heard of the mythology of Greece and the cults surrounding the Roman emperors. Yet those were the religions of city-states not far removed from our own modern societies. Far less well known are the religions of the agricultural communities that preceded the advance of Greco-Roman civilization.

In several of the latter, images of corpulent human figures played an important role. Because some of these figures are recognizably female in shape, archaeologists sometimes refer to them as "fat ladies" and associate them with the celebration of fertility, both human and agricultural. On one small group of islands, those of Malta, such figures became the object of an infatuation that was closely linked to the construction of the earliest free-standing public stone buildings in the world.

Those temples and the underground burial chambers related to them contained many images of obese humans—some no larger than a few centimeters, others the size of giants—as well as of animals and phallic symbols. A collaborative project between British and Maltese archaeologists, of which we are the directors, has made spectacular discoveries about the artistic representations of the so-called mother goddesses. These findings have cast new light on

CAROLINE MALONE AND SIMON STODDART

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

SEATED PAIR of human figures is helping archaeologists revise their views of Maltese prehistory. The statue was unearthed (*left*) from a subterranean burial complex on the island of Gozo.

CAROLINE MALONE AND SIMON STODDART

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

how certain religious practices evolved on Malta and perhaps on why they eventually disappeared. They suggest the religion itself encompassed much more than a worship of human fecundity. They also tell a cautionary tale about what happens when a people focus too much energy on worshiping life rather than sustaining it.

Traditionally, archaeological discoveries in Malta have been interpreted—or perhaps we should say misinterpreted—against a backdrop of broad conjecture about the significance of mother goddesses. Figurines fitting that general description date from the Upper Paleolithic era (about 25,000 years ago) to the dawn of metal-using societies in the Neolithic era. A few have been found in western Europe, but the yields have been much richer at sites in Egypt, the Levant, Turkey, Greece, Cyprus and the Balkans. The most elaborate figures come from the islands of Malta in the third millennium B.C.E.

Unfortunately, many of these figurines are far less informative than they might once have been because of the unscientific ways in which they were collected. The dating of the figures is often inaccurate. The records of where and how they were situated are often incomplete, so we cannot know whether the figures were peculiar to burial sites, shrines or houses. We do know that in the Balkans such figures were kept in houses inside specially constructed niches in the walls. In Turkey, at the site of the eighth millenium B.C.E. settlement Çatalhöyük, the finest figurines of clay and stone were associated with the burials of high-status people in special shrines, whereas cruder figurines were found in houses [see "Women and Men at Çatalhöyük," by Ian Hodder, on page 34].

The discovery of similar figurines at far-flung sites and from disparate eras inspired a long tradition of scholarly speculation about a widespread prehistoric religion based on the worship of the mother goddess. In the middle decades of this century, for example, some archaeologists tried to show that a cult of the Eye Goddess (so called because of eye motifs on Mesopotamian idols) diffused throughout the entire Mediterranean. More recently, claims have been made that the Balkans were the center of an Old European religion.

Most modern scholars appreciate that the early cults were radically different in each prehistoric society and that the cults of domestic life were distinct from the cults of death and burial. The example of Malta demonstrates that variation most emphatically. Elsewhere in the Mediterranean, the cults generally involved simple domestic rituals; little effort was invested in religious art or architecture. In Malta, however, the worship of corpulent images gradually blossomed into a consuming passion. That fixation may have been able to take root because conditions there enabled a closed, isolated, introverted society to develop.

Today the dry, rocky, hilly islands of Malta seem inhospitable to farming communities. Little soil or vegetation is present, and obtaining fresh water is a problem. Yet the geologic evidence suggests that between 5,000 and 7,000 years ago, a far more inviting scene greeted the early inhabitants. Those people probably cleared the fragile landscape of its natural vegetation fairly rapidly. Thereafter, severe soil erosion gradually robbed the islands of their productivity. The resulting environmental fragility may have caused agricultural yields to be unpredictable.

ISLANDS OF MALTA are dotted with numerous groups of large stone temples. One noteworthy burial site, the hypogeum of Hal Saflieni (*right*), was discovered in the early part of the 20th century. The authors are studying another burial site within the Brochtorff Circle.

That stress may well have shaped the strange and often extreme society that one finds portrayed in the archaeological record of ancient Malta.

The prehistoric archaeology of the Maltese islands is famed for its many huge stone temples. The number of them is staggering: some 20 groups of temples dot the islands, most containing two or three individual massive structures. Radiocarbon dating has indicated that they developed over roughly a millennium, from approximately 3500 to 2500 B.C.E. Because of their prominence in the landscape of Malta and Gozo, the two largest and most populous of the islands, the temples were always obvious targets for enthusiastic archaeological investigations, particularly during the 19th century. Those early workers cleared the rubble and other deposits from the temples long before scientific archaeology had developed. Little effort was made to specify the exact positions of the unearthed artifacts; in particular, the contexts of the cult idols were rarely re-

LUCY READING-IKKANDA

THE AUTHORS

CAROLINE MALONE, ANTHONY BONANNO, TANCRED GOUDER, SIMON STODDART and *DAVID TRUMP* have extensively explored the ruins of ancient Maltese culture and contributed to its modern understanding. Malone is senior tutor and fellow in archaeology at Hughes Hall, Cambridge. Bonanno is professor of archaeology at the University of Malta. The late Tancred Gouder was director of museums at the National Museum of Malta. Stoddart is senior lecturer and fellow in archaeology at Magdalene College, Cambridge. Trump was most recently tutor in archaeology in continuing education at the University of Cambridge and from 1958 to 1963 curator of archaeology at the National Museum of Malta.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

corded. Not much can be done now with that incomplete evidence, other than to appreciate the sculptors' high level of skill.

Though mostly stripped of its cult images and other decoration, the architecture of the Maltese temples still survives. The design of the temples is regular: each consists of a curved stone facade overlooking an open forecourt. The facade usually has a formal entrance, marked by enormous carved stones and a capstone, that leads to a central corridor. Lobe-shaped apses open onto this corridor at either side and ahead, as in a cloverleaf. The apses often had stone altars (which were frequently carved with spiral or animal designs), carefully plastered floors and walls, and other decorations painted with red ocher, a pigment probably imported from Sicily. They also feature tie-holes, which in some cases were perhaps for fastening animals to the walls, and holes in the ground that were evidently for draining liquids. In many instances, substantial quantities of animal bones, particularly those of sheep and goats, were found together with drinking vessels and sharp flint knives. All these details suggest that sacrifices and feasting may have played an important part in the rituals performed in the temples.

Some information about the layout of the furnishings survived in the temples of Tarxien, which were excavated between 1915 and 1919. The lower half of an enormous statue of a "fat lady" was found in the temple precinct. Next to it is an altar within which the remains of food were found. The altar faced the carved figures of animals that may have represented sacrifices. Deeper within the recesses of the temple, excavators found the images of people who may have been priests, caches of precious pendants and even architectural models of the temples themselves.

The discovery in 1902 of the hypogeum, or subterranean burial chamber, at Hal Saflieni added another dimension to the cults of early Malta. Construction workers stumbled across this remarkable site while excavating cellars and foundations for new buildings in the surrounding town of Pawla. Before any skilled archaeologist was called to the scene, most of the chambers were emptied without documenting their contents; the rich assemblage of human remains and grave goods they must have contained probably ended up as fertilizer in nearby fields. A proper study of the hypogeum was finally conducted a few years later by Themistocles Zammit, the curator of the National Museum of Malta and the father of Maltese prehistory. He attempted to salvage what information he could from the near-empty chambers cut in the rock.

Zammit estimated that a fantastic number of individuals—between 6,000 and 7,000—had been buried in the 32 chambers of the hypogeum complex. They had been interred along with grave gifts of pots, obsidian and flint tools, jewelry consisting of beads and stone pendants, and clay and stone figures of obese people and animals. One of the most striking figures is the Sleeping Lady of the Hypogeum. This statuette shows a rotund female lying on her side on an elaborate woven bed. She is clothed in gathered skirts, and her hair is dressed in a small, neat bun.

The various passages and chambers of the site strongly resembled the temples aboveground, with upright stone blocks spanned by lintels, steps, hinge holes for barriers and perhaps painted decorations. Nevertheless, the primary function of the hypogeum was clearly for burial, as the thousands of bones attest. Yet it may have been more than simply a huge tomb. Its elaborately carved form, so similar in design to the temples, hints that it was also a temple for the dead, central to the rituals of death, burial and the afterlife.

The great number of figurines from

A fantastic number of individuals—estimated between 6,000 and 7,000—had been buried in the 32 chambers.

NATIONAL MUSEUM OF ARCHAEOLOGY, MALTA

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

"FAT LADY" figurines representing mother goddesses were made by many early Mediterranean cultures, but those from Malta are the most elaborate. Not all the human figures from Malta are clearly female, however, which suggests that the ancient religion there involved much more than just the worship of human and agricultural fertility.

both the temples and the ornate burial hypogeum of Hal Saflieni have fueled ideas (some plausible, some fantastic) about the supposed fertility cults and rituals of Malta. Some archaeologists have hypothesized that Maltese society may have been a powerful matriarchy dominated by priestesses, female leaders and mother goddesses. Those theories were always based on an implicit faith in the meaning of the artifacts—a faith as devout, in its way, as the prehistoric religion itself but lacking much scientific foundation.

In recent years, an excavation at the site of the Brochtorff Circle on Gozo has uncovered important evidence about the prehistoric rituals of death. The Brochtorff Circle, a megalithic enclosure on the summit of the Xaghra plateau, was first uncovered in the 1820s by Otto Bayer, the lieutenant governor of Gozo. Vague historical records suggest that a typically haphazard treasure hunt at the site followed, from which no findings or documentation survived. Those efforts obliterated all surface traces of the structure. Fortunately, though, a roving Maltese artist, Charles Brochtorff, made several sketches of the work while it was in progress. His accurate, detailed watercolors and engravings show a site that consists of a stone wall and entrance that encircle a huge rough hole at the center; several megaliths also stand within the enclosure. In one drawing, a man is shown climbing from the hole, holding an object shaped like a human skull.

That series of pictures was the only clue left to suggest that an archaeological site was located on the plateau. It served as a starting point for our team, which set out to rediscover whatever remained underneath the flat field, guided by local archaeologist Jo Attard. Using the most up-to-date scientific techniques, such as ground-penetrating radar, we conducted topographic and geophysical surveys of the area to assess the nature of the buried rock. In 1987 we succeeded in once again locating the Bayer excavation within a circle that had been found 200 years earlier.

Since then, hard reexcavation has been done at the site. Over an area of about a quarter acre, we needed to remove not only the 19th-century backfill but also the rubble from cave collapses that had filled several deep natural cavities to a depth of more than four meters. Ultimately the true nature of the site became clear, and the rich array of recovered artifacts and human remains testified to its importance.

After the previous depredations at the site, we wanted to ensure that it was reexcavated with all the care and precision available to modern science. We therefore recorded and photographed every item at the base level of the caves in situ from several directions for a three-dimensional record of its position and appearance. Samples were taken for dating and also for studies of the local environment and subtle stratigraphy of the site. Paleoanthropological methods helped us to reconstruct a profile of the buried human population. We kept scrupulous computer records.

Unlike the great hypogeum of Hal Saflieni on Malta, which consists mainly of artificial carved chambers, the Brochtorff site on Gozo is fundamentally a series of natural caves with numerous interconnecting chambers. Erosion and perhaps earthquakes have cracked the

CAROLINE MALONE AND SIMON STODDART

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

thin, rocky roof of the caves, resulting in several meters of rockfall and jumbled archaeological deposits. The caves were crumbling even 5,000 years ago. The prehistoric community, which by that time had already been using the caves for the burial of the dead for perhaps 1,000 years, began to insert carved stone supports under the cave roof in a vain attempt to control the collapse.

The burial complex at the Brochtorff site was in use for about 1,500 years, a period spanning several stages in the evolution of Maltese religion and society. In the early Zebbug period between 4000 and 3500 B.C.E., burial rituals were simple. The dead were placed in collective chambers that were either in caves or in tombs cut into the rock. Each chamber may have held the members from a single family or lineage group. One such tomb was found inside the circle in 1988. The burial rites evidently included the progressive removal of bones from earlier burials to allow space for later ones; the large removed bones may have been dumped in other parts of the caves.

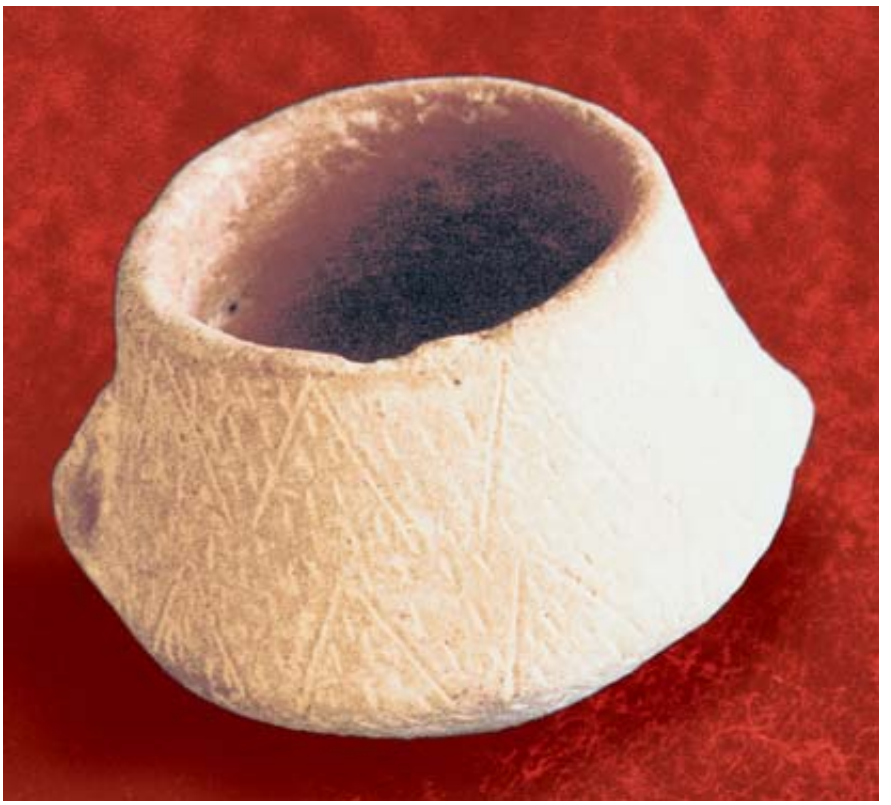
A variety of gifts were interred with the dead: pottery, bone and stone beads and pendants, stone axes made of metamorphic rocks, flint and obsidian blades, shell pendants, and shell and bead necklaces. The bone pendants often have budlike appendages suggestive of arms and heads. Red ocher was spread lavishly over the grave goods and also over the dry white bones of the dead (perhaps in a symbolic attempt to restore them to life). At the entrance to one of the chambers stood a small upright monolith, a so-called menhir, bearing a crudely carved face that guarded the doorway.

The later burials, which were contemporary with the great Tarxien period of temple building, were different. The emphasis on small family groups appears to have been supplanted by a more ritualized and elaborate cult of the dead. Part of the evidence for that conclusion comes from the megalithic construction of the Brochtorff Circle itself. The builders enclosed the opening to the cave with a wall and oriented its entrance eastward through the massive upright stones. In so doing, they integrated the entire site with the Ggantija temple, 300 meters away and on a lower terrace of the plateau.

Inside the caves the Tarxien builders leveled the earlier burials to provide a fresh (albeit bone-riddled) surface for the installation of stone monuments. The niches and smaller caverns were subdivided with pairs of upright stones and rough walls, which created additional, enclosed places for burials. At the center of the main cavern, the Maltese builders set up megalithic slabs in a semicircle, at the heart of which was a huge carved stone bowl. The stonework surrounding this bowl was elegant, and there is evidence that some of it included animal figures and pitted patterns. The builders did not apply red ocher as liberally as their predecessors did, and they painted only a few of the nearby slabs. Available supplies were made to stretch further.

Bodies were buried in the compartments around this central shrine. One noteworthy burial site was a natural cavity in the cave floor where hundreds of bodies were laid to rest. At first sight, the remains seemed incomplete and in confusion. Our further work has shown, however, that the bones from

The burial rites evidently included the progressive removal of bones from earlier burials to allow space for later ones.

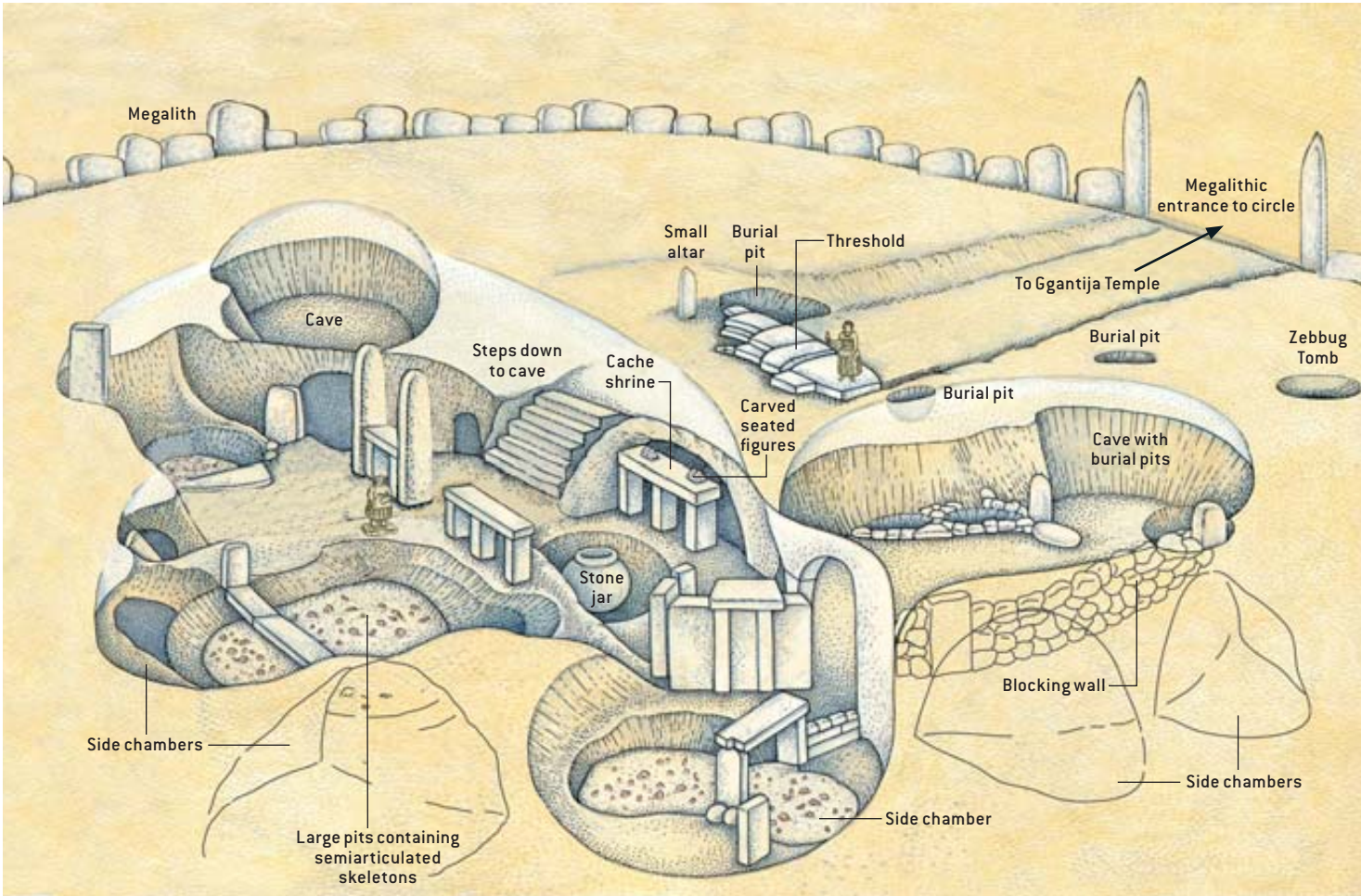


SMALL CERAMIC POT was used to hold red ocher, a pigment daubed on ritual figures and human bones during Maltese burial rites.

CAROLINE MALONE AND SIMON STODDART

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Underground Burial Chambers



BROCHTORFF CIRCLE marks a cave complex that the inhabitants of Gozo used for burials between 4000 and 2500 B.C.E. Treasure hunters found the site and then obliterated it in the 19th century, but in 1987 the authors and their colleagues found it again and reexcavated it. An aerial photograph (*below*) shows the site as it appears today. The drawing (*above*), based on a reconstruction by Steven Ashley, shows a partial reconstruction of the burial complex based on the most recent work. Thousands of human remains, many still adorned with ceremonial red ocher pigment, are clearly identifiable within certain pits in the cave floor (*right*).

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

many bodies had been carefully sorted and stacked by type: skulls in one place, femurs in another and so on. This pattern suggests that as part of the burial ritual, old bodies being removed from compartments were disarticulated.

Some 220,000 human bones, which probably represent more than 800 individuals, have now been studied. The early results paint the ancient Maltese as a typically Mediterranean people—stockily built and of medium height. They show some distinctive characteristics, such as a digastric fossa, a well-formed groove on both sides of the skull that is found in some other populations. Their health was apparently very good, with few dental problems or other detectable illnesses. The same anthropological features are present from the earliest Zebbug people to the late Tarxien population, which evinces little or no change in the genetic makeup of the early Maltese community. The changes in their customs and cults were therefore probably not the result of foreign immigration. Scientific studies of the bones will continue over the next decades, providing one of the first and possibly the biggest samples of research on an early Mediterranean population ever undertaken.

The only grave goods with these Tarxien people (which have been dated by the radiocarbon method to around 2800 B.C.E.) were small, carefully modeled ceramic statuettes of obese human figures. These figurines are of ambiguous sexuality, even though they have distinctive accumulations of fat on the buttocks. Most show no primary characteristics of sexuality (such as breasts). Their discovery in that location was highly significant: it marked the first secure association of fat ladies with burial sites instead of shrines or temple altars.

On the ground surface, at the monumental entrance leading down into the caverns, another pit was also filled with human remains. Among them were many males whose body parts had been rearranged after being taken from some other burial place. Almost no grave gifts accompanied the bones. Small altars at either end of the megalithic pavement beside the burial pit may have been used for preliminary sacrifices and obeisances before the priest and the assembled mourning community ventured down into the foul, reeking caves of the dead.

Striking Sculptures

THE MOST EXCITING discoveries from the Brochtorff site, aside from the human remains themselves, are small stone sculptures that have changed our views about the role of art in the ancient local religion. The prehistoric Maltese of the Tarxien period seem to have invested most of their artisanship and craft into cult objects that were more than mere grave gifts. For example, a ceramic strainer and a unique stone sculpture were unearthed from near the stone bowl in the megalithic shrine. The strainer was probably meant to be used with the bowl, perhaps for straining out unwanted objects or for sprinkling liquids onto bodies.

The sculpture shows a beautifully carved and painted pair of obese figures. They are seated on an intricately carved bed, daubed with red ocher, that shows woven struts on the underside and curvilinear designs on the upper. The fat figures are not explicitly male or female. They wear the familiar pleated skirts, painted black, of the finest Maltese cult figures. The head of one figure sports a haircut that includes a pigtail at the back. The other's head is missing. Both figures hold objects on their laps: one a tiny dressed person (who may be a baby), the other a cup.

Aside from the sculpture's fine craftsmanship, it is astonishing because the portrayal of several humans together is almost unknown from that period in Europe: even individual figures, other than the fat ladies, are uncommon. A few artifacts with features that are reminiscent of this sculpture have been found elsewhere in ancient Malta, such as the fragments of carved beds and the terra-cotta Sleeping Lady of the Hypogeum. Nevertheless, this discovery is one of the earliest and most thought-provoking groups of sculpture from European prehistory.

The other major find was a cache of nine carved stone idols, which were also closely associated with the stone bowl in the central shrine. The objects must originally have been wrapped tightly in a bag or box: when they were discovered in 1991, they were all lying one above the other, having fallen from the structures surrounding the bowl. Six of the objects represent human figures: flat, triangular shapes attached to carvings of human heads. The six range from poorly detailed rough-outs to skillfully executed cult idols. Two of the most detailed figures have pleated skirts and belts, and one wears an elaborate crested circlet, suggestive of metal, around its head. The faces of both these figures show eyes and lips and well-defined noses. A third figure is simpler and has no costume other than an exquisitely sculpted cowl headdress. Two more have plain bodies and bobbed hair. The last of the six is a crude rough-out that shows only the lines that the finished sculpture was to follow.

The three other idols of the nine are small and individual. One has a pig's head, the second a well-carved human head on a phallus-shaped pedestal and the third a head supported by two legs. Along with these extraordinary objects was a miniature Tarxien pot filled with ocher, perhaps for smearing on idols.

No parallels for any of these strange objects have ever been found elsewhere in Malta or the central Mediterranean. Even so, our knowledge of the context in which they appear is informative. Whereas the figures associated with the dead in their burial chambers are fat ladies, those from the central shrine are much more complex. One cannot find an emphasis on images of female fertility in the shrine. Indeed, where the imagery is interpretable, it seems to be male and animal. The context of their discovery suggests that the shrine objects were the paraphernalia employed by the ritual specialists or priests and that their symbolism was meant to evoke much more than just a mother goddess.

Unprecedented discoveries at the Brochtorff Circle have encouraged us to reconsider the whole basis of ancient cults and religions in prehistoric Malta and Gozo. As the old ideas had sup-

preceding page: PATRICIA J. WYNNE, SOURCE: STEVEN ASHLEY AND CAROLINE MALONE *(drawing)*; CAROLINE MALONE AND SIMON STODDART *(photographs)*

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

SMALL STONE IDOLS were probably used by priests or other specialists in burial rituals at the Brochtorff Circle during the Tarxien period. The three at the top, representing human figures, show very different levels of detail and artistic execution. The other three, which invoke animal and phallic imagery (*bottom*), are more fanciful and individualized.

posed, the worship of fertility may well have been a component of the prehistoric religion. But the recent findings argue that it would be a mistake to concentrate exclusively on any one facet or historical period: the prehistoric religion of Malta was not only an infatuation with fat females.

During the Zebbug period between 4000 and 3500 B.C.E., the cult focused on the provision of caves and underground tombs as burial places. Accurate depictions of people do not seem to have played a part in the local rituals: the closest representations of human forms in the tombs are the very crude faces on the menhirs and the curious bone pendants with budlike arms and heads. Red ocher was the predominant decoration. Exotic axes of green stones and other objects made of flint and obsidian were also used as grave goods. In many ways, the early ritual developments appear to have paralleled similar trends in Sicily, where rock-cut tombs and simple collective burial rites were developing at the same time. The Maltese islands during this early period were still relatively fruitful and may not have been overpopulated.

But by half a millennium later, Malta seems to have been shaken by major changes. The erosion of the soil and other signs of environmental degradation may have become apparent; in this environment, population levels almost certainly began to pose problems. Artifacts from that period—the obese human and animal figurines and the phallic symbols carved in stone or bone and modeled in clay—point to the idea that the people had an obsession with the living world and its successful propagation through the descent group or lineage. Malta seems to have become an island world under powerful economic and environmental stress, where the communities were struggling to maintain their former standards of living and to feed the population. Yet fewer materials may have been imported during this time of crisis than in the more fruitful era. The prehistoric Maltese society seems to have let a fixation on sculpture and art replace contact with the world beyond the islands' rocky coasts.

That debilitating fixation may explain why the temples are so numerous on so small a group of islands. Some scholars have theorized that they were built by perhaps half a dozen rival clans or tribes, each competing for land and water. The colossal size of the temples, and the later architectural additions that made them even more prominent, could have been inspired by such a competitive spirit. Religious and cult influence and social control over the population may also have been inportant.

Cult activities seem to have reached a feverish pitch in the final phases of the Tarxien period around 2500 B.C.E. The society was becoming increasingly dominated by a religious hierarchy in which cult specialists or priests controlled much of the industry of the people. Vast amounts of human time and energy were invested in temple building, artistic endeavors and ritual feasts. The dead were honored within cults and linked to animals and human obesity. The people seem to have expended relatively little effort on the building of villages or domestic structures, on terracing or on farming methods. The obsession with the cults of the temples seems to have been complete.

Such obsessions are dangerous, and so it proved to be on ancient Malta. By about 2500 B.C.E. the community of the temple builders had ceased to build and perhaps even to use the monumental burial sites prepared by earlier generations. By 2000 B.C.E. the entire culture had disappeared and been replaced by very different religious practices that favored cremation burials. The burial

CAROLINE MALONE AND SIMON STODDART

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

hypogea, the cult of the fat ladies, and the other symbols of the living and the dead were completely abandoned.

The prehistoric religion of Malta might appear to be a failed experiment in the Mediterranean laboratory. Like many failures, however, it tells us more than a success might have. The extreme religious fervor of ancient Malta shows one of the possible results when societies are placed under severe pressures. Further careful excavations and reconstructions on Malta and at other Mediterranean sites should extend our understanding of the complexities and diversity of prehistoric society. Funerary deposits still lie intact at Brochtorff Circle and may one day offer further information.

Postscript

AFTER THREE MORE YEARS of fieldwork and 10 years of analysis, the major task of analyzing and publishing 220,000 human bones and the accompanying animal bones and figurative art is nearly finished, and publication of the final report is planned for 2005. Further details of figurative art identified in these last two seasons included many more corpulent clay figurines, an intriguing snail figurine, a pair of enigmatic "female torso" pendants, and a broken-up finely carved standing figure, originally almost a meter in height. We have also established the varied ways in which human bodies were displayed and displaced during the funerary rituals.

Since the original article was written, there has been much discussion about the creative context of Maltese religion. Key issues include the construction of prehistoric Maltese identity, the degree of interaction between the Maltese islands and the rest of the Mediterranean, and the fragility of the Maltese environment.

An identity of a people is generally constructed in contrast to another external identity, but when a population resides on an island, a key question is the level of knowledge achieved by the island population of their outside world, in this case some 85 kilometers to the north. In prehistory, that knowledge can be best measured by the analysis of imported material culture and the interpretation of the context wherein these imports are placed.

In prehistoric Malta, most cultural effort went into using the widely available local limestone and clay to create impressive monuments, sculptures and pottery. In the temples and mortuary sites, most imported items (greenstones, ochre and some fragments of pottery) were secreted away in their inner recesses. This suggests that knowledge of the outside world was deliberately restricted to the eyes of a few. But until archaeologists have excavated domestic sites on the Maltese islands, we will not know the relative importance of other imported materials, such as flint and obsidian, for a domestic economy that was essentially based on local agriculture. Without that knowledge of domestic sites, it is also very difficult to measure any demographic change on the islands. Nevertheless, it is now even clearer that the local prehistoric agriculture was practiced in a landscape already cleared of vegetation and therefore potentially vulnerable both to erosion and to shortfalls of water. Studies of land snails from the Brochtorff Circle (as early as 4000 B.C.E.) and pollen from Marsa on Malta near Valletta (as early as 3600 B.C.E.) confirm this relatively treeless landscape, similar to that of today.

The preoccupation with religion on Malta probably had a number of causes. It was clearly a means of projecting an identity for the prehistoric populations, but we suspect that knowledge of alternative (for example, Sicilian) identities was principally a preserve of the "priests" who controlled knowledge of the outside world. The religion also served, through the ideal images of corpulence, to forge a sense of continuity in the community, the lineage, and the family beyond the short-term cycles of life that govern all humans and more particularly the prehistoric Maltese. These same life cycles of the prehistoric Maltese could have been vulnerable to disruption because of the relatively isolated island location, with its cleared and fragile landscape on which its food supplies depended. The implicit lesson for the modern world remains the same: religious faith should not shield the eyes of the faithful from solving problems whose solutions are made clear by the use of observation, the basis of scientific analysis. SA

The extreme religious fervor of ancient Malta shows one of the possible results when societies are placed under severe pressures.

MORE TO EXPLORE

The Prehistoric Antiquities of the Maltese Islands: A Survey. J. D. Evans. Athlone Press, London, 1971.

Monuments in an Island Society: The Maltese Context. A. Bonanno, T. Gouder, C. Malone and S. Stoddart in *World Archaeology,* Vol. 22, No. 2, pages 190–205; October 1990.

Cult in an Island Society: Prehistoric Malta in the Tarxien Period. S.K.F. Stoddart, A. Bonanno, T. Gouder, C.A.T. Malone and D. Trump in *Cambridge Archaeological Journal,* Vol. 3, No. 1, pages 3–19; 1993.

Radiocarbon Dates from Malta. D. H. Trump in *Accordia Research Papers,* Vol. 6, pages 173–178; 1995–1996.

God or Goddess: The Temple Art of Ancient Malta. C.A.T. Malone in *Ancient Goddesses: The Myths and the Evidence.* Edited by L. Goodison and C. Morris. British Museum Press, 1998.

Towards an Island of Mind? C.A.T. Malone and S.K.F. Stoddart in *Explaining Social Change: Studies in Honour of Colin Renfrew.* Edited by J. Cherry, C. Scarre and S. Shennan. McDonald Institute, 2004.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Pakistan

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Recently excavated artifacts from Pakistan have inspired a reevaluation of one of the great early urban cultures—the enigmatic Indus Valley civilization

Uncovering the keys to the LOST INDUS CITIES

By Jonathan Mark Kenoyer

COLORFUL STONE BEADS such as those from Mohenjo Daro (*above*) were more than mere baubles for the ancient peoples of the Indus River Valley civilization; they served as symbols of wealth, status and power. Skilled artisans developed sophisticated craft technologies to fabricate these and other kinds of ornaments for the elite classes of this early urban society. Archaeologists interpret the strikingly carved soapstone figure, the so-called priest-king (*left*), to be a member of the Indus Valley ruling class.

RANDY OLSON *Aurora Photos*; DEPARTMENT OF ARCHAEOLOGY AND MUSEUMS, GOVERNMENT OF PAKISTAN (*left* and *above*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

INDUS MERCHANTS stamped glazed seals bearing animal images and the undeciphered Indus writing symbols into soft clay tags attached to trade goods to indicate ownership and accounting information.

In the mid-1980s, during our first few seasons excavating the long-dead city archaeologists call Harappa, my colleagues and I watched the passage of the annual spring fairs without realizing their implications for our studies of the ancient Indus civilization. Every year in Pakistan's Indus River Valley, people living in villages travel to larger towns to attend festivals called *sang*—"gathering fairs" where musicians, performers and circus troupes entertain the crowds while itinerant merchants and traders hawk their wares. During the single-day event, women present religious offerings to professional pilgrims, who, on the women's behalf, will later petition the Sufi saint Sakhi Sarwar for healthy children, especially sons. At day's end the holy sojourners and their colorful secular entourage make their way by foot and donkey cart to the next town along the region's age-old trade routes [*see illustration on page 28*].

Eventually various groups of devout wayfarers arriving from different parts of the country converge on the saint's tomb hundreds of kilometers away in the Baluchistan hills. Here they deliver the alms and prayers they have collected during their treks to the saint's precinct. Making their way along the same path the next year, the pilgrims bear salt and sacred earth from the distant shrine, tokens of favor for the fortunate mothers and their precious newborns.

Our view of the *sang* changed significantly when we began digging inside the southern gateway of Harappa, just adjacent to the traditional fairgrounds. As we sifted the uppermost soil from the newly opened trenches, we recovered modern pottery shards, hundreds of pieces of recently manufactured glass bangles, some contemporary coins, lead pellets from the air guns fired at balloons during the festival, fragments of plastic and metal toys, even a gold earring. Just below the surface levels, however, we began finding ancient Harappan artifacts that were surprisingly similar to the modern flotsam: broken pottery, terra-cotta bangles, clay marbles, toy carts, figurine fragments, and, occasionally, inscribed tablets and weights that were probably used in trade and taxation at the city's entrance.

The buried remains suggested that a thriving market existed in the vicinity and that the activities conducted there some four millennia ago were not unlike those occurring even now. Our further work has confirmed that belief. As today, nearby villagers would come to the big city on special market or festival days to participate in ceremonies, to renew family or clan ties, or to buy (or barter for) specially crafted items such as ornaments and pottery. Along the very same pathways trod by present-day pilgrims and their followers, raw materials from the hinterlands once arrived at the gates of Harappa, where the artisans in the city's many workshops transformed them into the finished luxury products that were later purchased by local elite personages and shipped far afield for export markets. Then, as now, people in the Indus Valley wore ornaments and jewelry to demonstrate their wealth and status. To modern observers, the continuity of day-to-day life in this region from deep in the past to the present is rather astounding. As archaeologists, we can try to determine whether these similarities result from cultural choices or from the fact that the available materials and technologies have not changed much over the millennia.

The enigmatic Indus Valley civilization was one of the four great early Old

Overview/*Crafts as Cultural Clues*

- The ancient Indus Valley civilization, which first arose in what is now Pakistan and western India after 2600 B.C.E., is the least known of the four major early urban cultures in the Old World, which included Mesopotamia, Egypt and China.
- With no "Rosetta stone" to rely on, linguists have failed to decipher the ancient Indus writing, so researchers must study stone beads and other surviving evidence to try to understand the social, economic and political structure of this once extensive state.
- Through careful investigation, scientists have reproduced the techniques master craftsmen used to make the many ornamental, commercial and ritual artifacts excavators have recovered from the long-buried ruins of the Indus cities. Reading their fine handicrafts for clues, archaeologists are at last developing a more detailed portrait of this extinct civilization.

RANDY OLSON *Aurora Photos;* HARAPPA ARCHAEOLOGICAL RESEARCH PROJECT AND DEPARTMENT OF ARCHAEOLOGY AND MUSEUMS, GOVERNMENT OF PAKISTAN

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

World state-cultures, along with Mesopotamia, Egypt and China's Yellow River civilization. But much less is known about it because, unlike the other ancient urban cultures, linguists have yet to decipher the Harappan script we see on recovered seals, amulets and pottery vessels. In our ongoing attempt to understand how the now vanished people of the Indus culture ordered their society and to determine the sources of political, economic, military and ideological (religious) power in this remarkably extensive and urbanized state, my co-workers and I have to draw clues from the miscellaneous material we dig up and from the layout and architecture of the cities and settlements we excavate.

The Harappan writings have not been totally useless, however. Although our inability to translate the symbols that artisans and others inscribed on objects has prevented us from learning directly how certain individuals and communities gained and maintained power, we have gleaned insights from examining the context of the writing's use. These studies, together with recent analyses of the advanced crafts that have survived the centuries at Harappa, have begun to yield a new understanding of the social power structure in the Indus civilization.

Hidden Cities

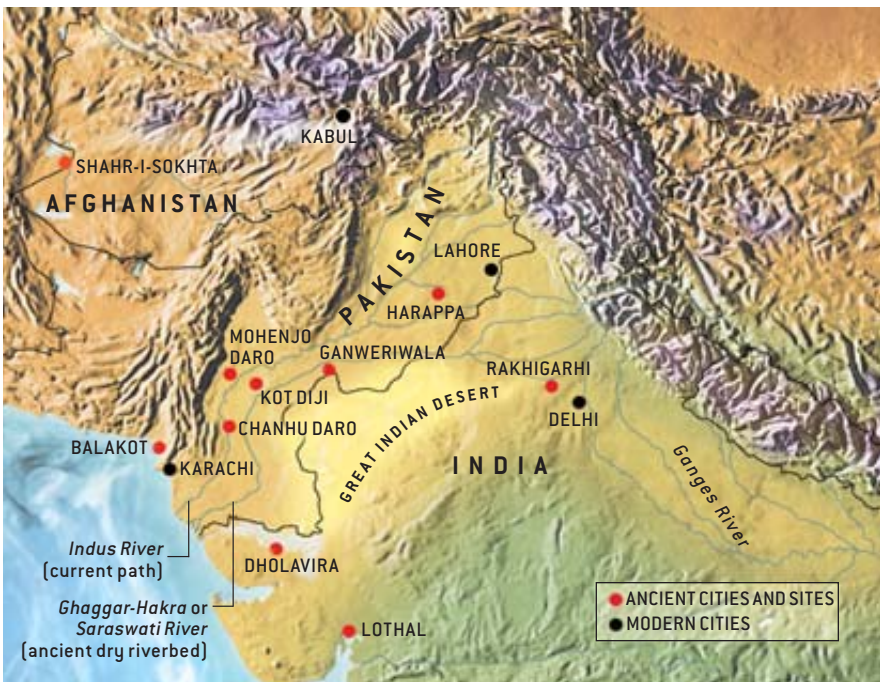
IN THE 1920S archaeologists excavating old mounds of soil and refuse that covered the two large Bronze Age cities of Harappa and Mohenjo Daro ("Mound of the Dead" or "Mound of Mohen") in what are now the Pakistani provinces of Punjab and Sindh brought the Indus civilization to the world's attention. That a major state had flourished on the rich floodplains of the great trans-Himalayan river was unexpected. Subsequent surveys and excavations in western India and Pakistan have uncovered more than 1,500 additional settlements distributed over an area the size of western Europe and twice that of Mesopotamia or ancient Egypt. Although the Indus Valley people did not produce monumental stone carvings and did not bury their dead with their wealth, they constructed large, well-planned cities and made exquisite luxury items that were traded and exported to distant markets in the Persian Gulf, Central Asia and Mesopotamia. The similarities in site layout and artifact style throughout the Indus region reflect a surprisingly uniform economic and social structure.

In 1986 the late George F. Dales of the University of California at Berkeley established the Harappa Archaeological Research Project, a long-term multidisciplinary study effort that I now co-direct with Richard H. Meadow of Harvard University and Rita Wright of New York University, in collaboration with Pakistan's Federal Department of Archaeology and Museums. We conduct on-site investigations and laboratory research to study the original Harappan settlement and to trace the evolution of the larger city that emerged at the site. That work has revealed several phases of development.

The Indus cities established their economic base on agricultural produce and livestock, supplemented by fishing and hunting. Both the common people and the elite classes derived additional income from the production and trade of commodities, including cotton and woolen textiles as well as a variety of craft items.

The earliest village settlement at Harappa (called the Ravi phase) dates from before 3300 B.C.E. to around 2800 B.C.E., a time when the Sumerians were building their first ziggurats and elaborately decorated temples and the Egyptians were burying their rulers and vast hoards of wealth in mud-brick tombs. Farming an environment similar to the agricultural lands of the Fertile Crescent in the Middle East, the ancient Indus peoples herded cattle and cultivated wheat, barley, legumes and sesame. Specialized craft technologies spread among the early settlements along trade networks, which likewise disseminated a shared set of religious symbols and artifact styles throughout the region.

Archaeologists have found other small farming communities from this period to the north and south of Harappa along the Ravi River, but none of these hamlets expanded into a larger town. In the limited exposed area of the Ravi-period Harappa, investigators



EDWARD BELL

INDUS VALLEY CIVILIZATION, which arose some 4,800 years ago, eventually included more than 1,500 cities and settlements spread over an area the size of western Europe in present-day Pakistan and western India.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

have turned up signs of the production of both terra-cotta and stone beads and bangles. The terra-cotta items were probably worn by children or commoners, or both, whereas the more exotic stone and seashell ornaments most likely adorned local upper-class populations. Through careful analysis of the raw materials and comparison to known source regions, archaeologists have shown that some of the raw materials used by the early Ravi craftsmen arrived at the site from 300 to 800 kilometers away. Impressions of woven fabric on small terra-cotta beads provide evidence of textile production, possibly of both cotton and wool.

This early site also contains the first indication of abstract symbols, or pictographs, scratched onto pottery. Current studies suggest that some of these symbols were retained in the later formalized Indus script, much as ancient Mesopotamian and Egyptian symbols on pottery and clay tablets from around 3500 B.C.E. and 3200 B.C.E., respectively, later found their way into cuneiform and hieroglyphic writing.

Between 2800 and 2600 B.C.E., Harappa became a thriving economic center. Physically, it expanded into a substantial town containing two walled sectors covering an area of more than 25 hectares—about the size of several large shopping malls. In the meantime, many related villages grew up in scattered sites nearby. During this period, called the Kot Dijian (after the site of Kot Diji to the south), artisans developed new craft technologies for making widely distributed products such as gray fired bangles and faience (a form of glazed pottery), the fabrication of which usually involved the use of high-temperature kilns [*see box on page 32*].

At the same time, increasing quantities of stone and other raw materials were being transported to Harappa, probably by oxcarts and flat-bottomed riverboats. Toy bullock carts and wheels made of terra-cotta have been found at Harappa from this period, and the later use of carts and boats is well documented. Archaeologists have also recovered figurines of cattle and humans painted with what appear to be woven fabrics, a sign of growing textile production and the importance of clothing, not only for functionality but for public display.

A formal writing system, known as the Early Indus script, emerged in this phase, as evinced by its appearance on numerous pottery fragments and in impressions that a seal, or stamp, made in clay. Merchants employed seals to indicate ownership of storerooms or bundles of goods by stamping clay tags, or bullae, over a cord or a secured door. These square seals, carved in intaglio with geometric or animal motifs, served as economic documentation. Because only a few seals have been discovered, it is likely that they were used by individuals or communities with considerable power, such as landowners, merchants and religious leaders.

Excavations have turned up other signs of economic evolution during the Kot Dijian period. In particular, scientists unearthed a tiny cubical limestone weight. The stone cube weighs 1.13 grams, which corresponds directly with the standardized weight system of the later Indus cities. Its recovery indicates that a system of determining value by weight, possibly for tax or tribute, was established in Harappa two centuries before it became widespread throughout the Indus Valley.

Many religious symbols of horned human forms and ritual designs on pottery began to appear at Harappa and in far-flung corners of the Indus region during the Ravi and Kot Dijian periods, indicating the spread and synthesis of religious and cultural ideas. Whereas in ancient Egypt and Mesopotamia military conquest achieved the integration of distinct regions into single states, this pattern has not been seen in early Indus settlements. The first settlers at Harappa seem to have exploited the rich agricultural and grazing lands along the Ravi River to sustain themselves as they built economic and political power through craft production and trade and then legitimized their standing through religious practices rather than warfare.

The Indus people constructed extensive, well-planned cities and made exquisite luxury items that were exported to distant markets.

RANDY OLSON *Aurora Photos*

EXULTANT RELIGIOUS PILGRIMS make their way along the age-old Indus Valley trade routes one town a day, bringing prayers and offerings of the faithful to a distant holy site.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

BIT BY BIT, Pakistani excavators uncover the massive walls of the lost city of Harappa as the author (*far right, in group*) explains the site's significance to visitors.

The fully urban phase of Harappa (termed the Harappa phase) began around 2600 B.C.E. and continued until around 1900 B.C.E. For seven centuries Harappa was one of the largest and most powerful economic and political centers in the Indus Valley, despite the seeming lack of an army. During the spring and late-summer trading seasons, the city would have hosted hundreds of traders who attracted thousands of people from the surrounding rural areas. Depending on the time of year, 40,000 to 80,000 people may have lived in the city. Wealthy patrons and entrepreneurial competition stimulated the development of new technologies and more extensive trade networks. Excavators have found distinctive pottery with widely used ritual motifs at all settlements throughout the greater Indus Valley, along with unique objects such as cubical stone weights, and seals inscribed with Indus writing and a motif depicting a mythical unicorn.

Far-Flung Trade

ALTHOUGH MOST TRADERS operated within the Indus Valley region, some materials were available only from more distant locales. The presence of raw materials and finished goods from Afghanistan and Central Asia indicates that merchants from these areas came to the city bringing lapis lazuli, tin, gold, silver and, perhaps, fine woolen textiles (which have since vanished). Traders would have carried back to the highlands cereal grains and livestock, as well as fine cottons and possibly even silks, but these items are not well preserved. Other nonperishable objects, such as long, elegant beads made of carnelian (a form of red agate) and shell bangles from the Indus Valley, have been dug up in Central Asia and Mesopotamia.

In its prime, Harappa measured more than 150 hectares in area—more than five kilometers in circuit, encompassing three large raised mounds and associated suburbs. The modern town of Harappa, with a population of around 20,000, still occupies a third of the ancient site. The city's architecture and street layout were organized to facilitate access to the different neighborhoods and to segregate the public and private areas. Massive mud-brick walls enclosed each of the raised mounds [*see illustration above*], and narrow gates limited access, permitting only a single oxcart to pass at a time. Masons employed kiln-fired brick to build multistory houses that were placed along north-south and east-west street grids. Major avenues spanned more than eight meters, and some featured central dividers that may have regulated two-way bullock-cart traffic.

Builders dug drinking-water wells in and around the city, and Harappan houses were equipped with bathing areas, latrines and sewage drains. Linked to larger mains, which eventually emptied outside the city walls, the sewers at Harappa would have removed wastewater from the habitation areas, depositing fertile sludge on the surrounding agricultural fields. Save for the Indus cities, no other city in the ancient world featured such a sophisticated water and waste management system. Even during the Roman Empire, some 2,000 years later, these kinds of facilities were limited to upper-class neighborhoods.

During this period, Indus scribes developed a sophisticated writing system comprising more than 400 symbols that the society's elite classes—including traders, landowners and ritual specialists—used as a mechanism for economic control and political power. Archaeologists do not know the language for which the script was developed, but it was probably used for writing more than one language, as was the case in Mesopotamia. We will never know for sure until someone discovers some form of bilingual tablet (an Indus Rosetta stone) that will help scholars break the code of the writing system.

This script became widespread in all the major urban centers of the Indus Valley. Its most prominent use was on seals that also bore animal motifs and ritual objects. The unicorn image [*see illustration on page 26*] is the most common (found on more than 65 percent of known seals), but other animals appear as well, including elephants, humped zebu bulls, water buffalo, bison, tigers and rhinoceroses. The animal symbols

THE AUTHOR

JONATHAN MARK KENOYER is professor of anthropology at the University of Wisconsin–Madison, where he teaches archaeology, ethnoarchaeology, experimental archaeology and ancient technology. His main focus is the Indus Valley civilization of Pakistan and India, where he has conducted research for the past 27 years. Kenoyer received his advanced degrees from the University of California, Berkeley. Since 1986 he has served as co-director and field director of the Harappa Archaeological Research Project, which is funded by the National Endowment for the Humanities, the National Science Foundation, the National Geographic Society, the Peabody Museum of Archaeology and Ethnology of Harvard University, the American School of Prehistoric Research, the University of Wisconsin, the Smithsonian Institution, the Kress Foundation, as well as private donors.

RANDY OLSON *Aurora Photos*

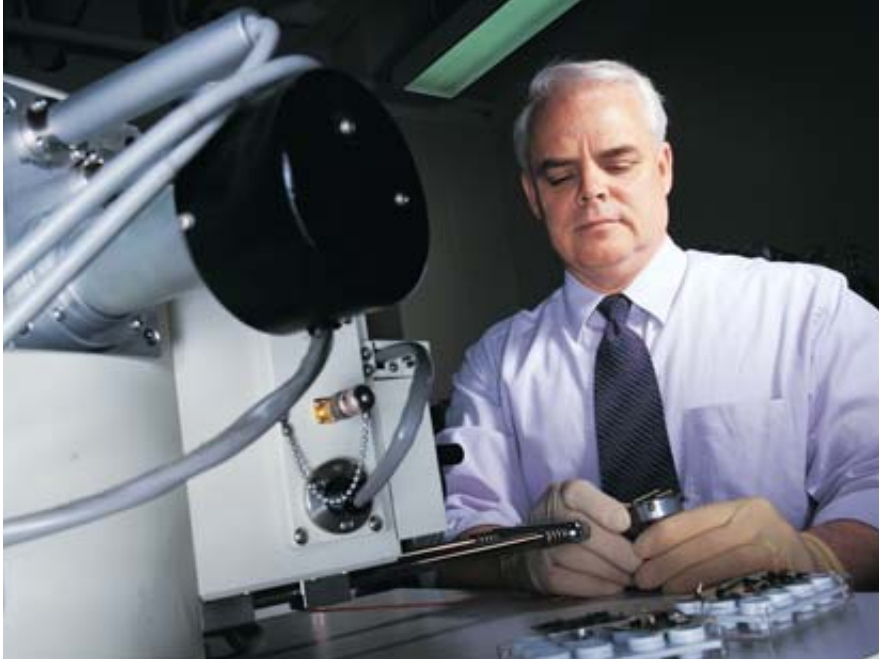
COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

may have represented important clans or official social classes; the writing probably listed the name of the owner and statements of legal legitimacy. The regular appearance of the unicorn sign indicates a widespread and powerful community, possibly merchants.

Beyond seals inscribed with writing and animal signs, excavators have found large pottery vessels for holding merchandise for trade etched with what may have been names of owners or consignees, together with a description of the contents. Investigators have interpreted examples of script scratched on bronze tools and gold jewelry as personal names or values.

We also see for the first time small tokens or tablets made of steatite (soapstone) incised with script and symbols. Because many of these items feature the same set of signs and what appear to be numbers, researchers think that they served as tools for accounting. The writing may indicate the owner's name, the commodity and its quantity, or the creditor to whom it is being presented. Similar tablets made of clay or faience that were stamped with a seal are found quite commonly in the later levels of the site. Some of these tablets have been intentionally snapped in two, possibly to indicate a contract between two parties, each of whom retained half until the transaction or work was completed. Distinctive copper tablets with script and animal motifs and their widespread use in Mohenjo Daro and Harappa are perhaps the earliest evidence for a form of city coinage in the Indus Valley.

Our discovery in 2001 of a workshop that manufactured seals and inscribed tablets at Harappa [*see box on page 32*], combined with the past 16 years of excavation at the site, has provided a new chronology for the development of the Indus writing. In the past, scholars had lumped all the seals and tablets together, but now we can demonstrate that different types of seals and tablets emerged at various times and that the writing itself may have changed over the years. We are currently trying to reach conclusions about the dating of the script changes and expect that this chronology will revolutionize the attempts at decipherment.



TELLTALE TOOL MARKS become visible when the author examines ancient Indus Valley artifacts with a scanning electron microscope at the University of Wisconsin–Madison.

Between 2300 and 1900 B.C.E. the urban populations in the Indus Valley expanded, and ornaments, tools and manufacturing technologies grew increasingly diverse. Archaeologists believe that these stylistic changes reflect two competing processes—the desire to differentiate among communities and classes within the cities and attempts to integrate these separate groups by promoting a common ideology.

In this period, we see writing combined with narrative mythological scenes indicating its use related to religious themes. Spiritual leaders most likely used seals and tablets to communicate the names of deities and rituals to the common people. Although researchers do not know the names of the Indus deities, we see the repeated motif of a seated male figure in a yogic position, wearing a horned headdress. In one set of narratives, a buffalo is sacrificed in front of the seated deity; in others, he is surrounded by ferocious wild animals. Female deities are also depicted on seals, sometimes with a horned headdress and fighting a tiger. A theme on many seals and impressions on clay tablets is that of a deity strangling two tigers, in some instances depicted standing on top of an elephant. A similar scene found in Mesopotamia is associated with the Gilgamesh epic, in which the hero strangles a pair of lions. The similarities between these motifs are evidence of shared concepts of power and dominance, but we do not know if the specific narrative spread from one region to the other.

As Harappa began to host more people from foreign lands, the elite classes probably felt the need to help legitimize their rule through public rituals and ceremonies that reinforced the principal religious traditions. In Mesopotamia and ancient Egypt, political and religious leaders accomplished this task by constructing massive stone or brick murals covered with religious and political propaganda depicting rulers conquering their enemies, but no similar artifacts have been unearthed in the Indus Valley.

Scribes developed a writing system that the society's elite used as a mechanism for economic control and political power.

DAVID NEVALA

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

What the Beads Say

OUR EXCAVATIONS at Harappa have yielded stone beads from all the major occupation phases of the site, indicating that the inhabitants produced them from the earliest settlement onward. Other evidence, particularly small figurines of city dwellers adorned with copious quantities of jewelry, reveals that Harappans often wore multiple strands of beads made from colored and patterned stones. Some of the bead-making areas that we uncovered were probably sponsored by the elite urban classes and produced rare, difficult-to-make beads as symbols of wealth, status and power.

From the unfinished samples and the remains of workshops, we have been able to document how bead styles and drilling techniques evolved over 1,400 years. This continual elaboration was probably stimulated by competition among workshops, market demand, and encouragement by wealthy patrons who sought more valuable and attractive ornaments.

The desire for high-quality beads, and thus refined fabrication methods, was strong even in the early Ravi phase (3300 to 2800 B.C.E.) of Harappa. Although it is relatively simple to make large stone beads, by far the most prevalent types during that period were quite small, between 1.5 and three millimeters in diameter and one to two millimeters long. These were particularly difficult to fashion because, for stringing, they needed tiny holes (one half to three quarters of a millimeter across).

MASTER ARTISANS of the Indus Valley used complex grinding, drilling and decorating methods to fashion colored minerals, often imported from far afield, into exquisite beadwork.

Some of the earliest beads were fabricated from steatite, a soft talc also known as soapstone. Archaeologists have recovered more steatite beads than any other type, and they occur in all parts of Harappa, dating from the Ravi phase through the Late Harappan (1900 to 1300 B.C.E.). Artisans easily bored holes in roughly formed beads of steatite using copper drills or even hardened acacia thorns about half a millimeter in diameter. Then they ground the unfinished beads to size and polished them on grindstones. Finally, the workers fired the beads in kilns, turning them white and converting the mineral into a harder, more durable form.

Some beads of steatite were left with a rough surface, which artisans coated with a finely ground silica frit (a glassy paste made of quartz powder) mixed with copper oxide, which yielded a blue-green glaze when heated. When fired at more than 850 degrees Celsius (1,562 degrees Fahrenheit), steatite crystals give off water and transform into much harder minerals, including cristobalite, enstatite and alumina. Many craftsmen of the Indus region practiced this kind of processing, which may have served as the foundation for later vitreous glazing procedures employed to fabricate faience ornaments, seals and tablets.

From the Ravi through the fully urban phase, bead makers in Harappa and other Indus cities also worked harder stones, such as agate and jasper, which required other drilling techniques: pecking with a stone or copper tool followed by boring with a harder variety of stone drill. Indus scholars have not replicated the pecking technique, so it is not well understood. But it is known that workers perforated some beads with hard stone drills made by shaping tiny slivers of stone into long, tapered cylinders. Hafted onto a thin wooden dowel and turned with a bow, these drills penetrated the beads halfway through from each side to form a continuous passageway for the string. This process was tedious, as both the stone drills and the beads were of approximately the same hardness.

Around 2600 B.C.E., Indus craftsmen discovered a much tougher stone drill, which we have called Ernestite, in honor of English archaeologist Ernest J. H. Mackay, who first discovered it in Chanhu Daro, Pakistan. These highly effective drills remain something of a mystery, and despite numerous studies and surveys, we have not yet discovered their precise composition or their source area. Ernestite seems to contain various minerals, and preliminary analysis suggests that it is a fine-grained metamorphic rock composed mostly of quartz, sillimanite, mullite, hematite and titanium oxide. Mullite is rarely found in natural form but is produced in modern high-temperature ceramic materials. Its occurrence in the drills hints that it is the by-product of intentional heating of the original rock, a process that was widely practiced by Harappan craftsmen for hardening steatite and making other rocks easier to chip.

Although we do not know where the first Ernestite drills were manufactured, so far they have been found only at sites in the Indus Valley, which implies that they were unique to that region. They gave the craftsmen a way to make exquisite carnelian beads that were worn by the Indus elites and traded to peoples in Central Asia and Mesopotamia, including Ur. People often wore the long carnelian beads as a belt of multiple strands that were held in place with polished bronze spacers.

Harappan bead makers used Ernestite drills for seven centuries, but around 1900 B.C.E. this drilling technique disappeared in the northern sites, perhaps because of the disruptions in trade networks that occurred at that time.

But the drilling of beads did not stop. Later artisans began perforating stone with hollow tubular copper drills used in combination with abrasives. The Harappans had always employed this method for hollowing out large stone rings and alabaster vessels, but then they miniaturized the technique, working with tiny tubular drills only a millimeter in diameter. Though not as efficient as Ernestite drills, the copper drills could perforate relatively hard stone beads by working halfway through from each side. *—J.M.K.*

DAVID NEVALA; HARAPPA ARCHAEOLOGICAL RESEARCH PROJECT AND DEPARTMENT OF ARCHAEOLOGY AND MUSEUMS, GOVERNMENT OF PAKISTAN

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Secrets of Harappan Glazing Techniques

FAIENCE, AN ATTRACTIVE glazed ceramic or stone featuring a lustrous sheen, is one of the complex craft techniques used by artisans to create high-status goods for elite consumers throughout Harappan history. Indus Valley faience was stronger than that from Egypt or Mesopotamia because it was made with partially melted quartz that was reground into a fine paste before a second firing, which fused the glassy powder to the core of the object. The Indus artisans needed a stronger form of faience because they were making different types of objects than those used in other regions, specifically faience bangles. They also produced tiny glazed beads and delicately molded tablets inscribed with written symbols used as credit tokens to keep accounts of goods coming into or moving out of the cities.

The Harappan elite classes employed faience not only for decoration and commerce but for ritual purposes as well. Tablets bearing narrative scenes may have been manufactured for special ceremonies and handed out to participants who had offered donations or sacrifices. Control of faience production techniques and the fabrication facilities was essential for Harappan elite classes to create and maintain their symbols of status and power.

Although workers produced faience from easily obtained materials, the technical expertise needed to process them into finished goods was highly specialized. Artisans partially melted powdered rock quartz in high-temperature kilns, using flux additives (fusion aids) made of plant ash to create a glassy frit. They then reground the frit, which they refired at around 940 degrees Celsius (1,724 degrees Fahrenheit) to create dense, glazed faience. When copper oxide or azurite was added to the frit, the resulting goods resembled turquoise or lapis lazuli but were much less likely to discolor when worn against the skin in a hot and humid climate.

Archaeologists have found manufacturing debris from faience production throughout the habitation layers in various parts of Harappa, but for 70 years they had failed to locate faience kilns. Our discovery in 2001 of a small faience workshop revealed that researchers had been looking for the wrong type of kiln. This find was akin to discovering the Harappan mint, because the workshop was also used for making steatite (soapstone) tablets, as well as beads and other ornamental objects—all objects of wealth.

Painstaking excavation and mapping of hundreds of artifacts from the workshop allowed us to reconstruct some of the processes used to fabricate beads, bangles and tablets. To produce molded faience tablets, craftsmen first sawed raw lumps of steatite into thin slabs and then carved them in reverse images to make molds. They used these molds to form tiny tablets that were placed in pottery containers made of sand and straw-tempered clay that would not melt down at the high temperatures needed for glazing. To keep the glazed tablets and other objects from sticking to the pottery firing container, the inside surface was thickly coated with a coarse white powder consisting of burned bone and sometimes ground-up steatite.

No kiln was discovered in the small workshop area, even though we recovered large quantities of charcoal, frothy vitreous yellow-green faience slag and broken firing canisters. After carefully examining the containers and vitrified supports used to stabilize them during firing, I began to suspect that the artisans had relied on a novel firing method. With the assistance of my graduate students, I was able to successfully test this procedure through an experimental reconstruction undertaken at the University of Wisconsin–Madison during the summer of 2001.

PRODUCTION of glazed stone and ceramics, known as faience, required Indus craftsmen to develop sophisticated coating and firing techniques. Minerals bearing copper oxide (*center*) were added to color the silica glaze blue so that it resembled precious turquoise or lapis lazuli.

It looks as if the Harappan faience glazers assembled two firing containers to form a mini kiln, rather than using bigger, more conventional firing structures. If heated in an open bonfire, they could reach temperatures high enough to glaze small objects. In the experiment, I replicated faience paste as well as the canisters and molds with materials and tools similar to those used by the ancient Harappans. We placed the molded prefired faience tablets and other test objects, including the steatite molds, in the container and covered it with a lid. Then we inserted conical supports to hold the lid up and to leave a small gap to allow flames to enter the miniature firing chamber. I positioned the canister on a low pile of firewood, covered it with more wood and lit the fire, adding more fuel to keep the assembly red-hot.

After about three hours of firing, the faience objects, just barely visible in the crack between the lid and the lower canister, began to glow a deep red-orange and to emit a distinctive odor. Using a thermocouple with a digital pyrometer, we were able to document the firing temperature at around 935 degrees C, the critical glazing point for Harappan faience. We maintained this temperature for about an hour by adding more wood.

After the mini kiln had cooled down, my students and I gathered around to observe the results. Though not identical to faience objects created by Harappan master craftsmen, fully glazed faience tablets and beads resulted. This first attempt of ours indicates that the canister-kiln technique would have been a highly efficient method for producing faience and fired steatite objects. Even more important was that the remains of the process—a pile of charcoal and ash, a cracked firing container, some discarded conical supports, charred bone, and a few rejected beads and tablets—closely resembled what we had found in the workshop at Harappa. *—J.M.K.*

DAVID NEVALA; HARAPPA ARCHAEOLOGICAL RESEARCH PROJECT AND DEPARTMENT OF ARCHAEOLOGY AND MUSEUMS, GOVERNMENT OF PAKISTAN

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

STANDARDIZED STONE WEIGHTS were employed by Harappan traders to measure out high-value merchandise for sale in urban markets.

Previously scholars argued that the Indus cities were suddenly abandoned around 1750 B.C.E., but our recent work at Harappa has clearly demonstrated that during its late phase, from 1900 to 1300 B.C.E., Harappa was indeed inhabited. In fact, signs that drains and city walls were not maintained provide proof of crowding and a breakdown of civic order. The remains suggest that the ruling elites were no longer able to control the day-to-day functioning of the urban center. This loss of authority must have eventually led to a reorganization of society, not just in Harappa but throughout the entire region that the upper classes had dominated for 700 years. Similar changes were occurring at the other big cities, such as Mohenjo Daro to the south and Dholavira in western India.

The crisis led to a cessation of the hallmarks of Indus elite culture. The distinctive pottery with ritual motifs and Indus script and traditional square seals with unicorn and other animal motifs disappeared. Cubical weights for taxation and trade fell into disuse, and the international trade networks began to deteriorate. Shells from the coastal regions no longer made their way to the northern sites, and lapis lazuli from the north failed to reach the sites in the plains. In Mesopotamia the texts that had recorded ongoing trade with a region called Meluhha, which is probably the Indus Valley, no longer mentioned it.

There seems to have been no single cause of the decline and reorganization of the Indus civilization but rather an array of factors. The growth of trade and the expansion of Indus settlements onto the Ganges River plain as well as into what is now the state of Gujarat in western India led to the overextension of the Indus political and economic system. Around 1900 B.C.E., one of the major rivers of the Indus Valley, the Ghaggar-Hakra (also called the Saraswati), began to shift its course and eventually dried up, leaving many sites without a viable subsistence base. These communities would have migrated to other farming regions or to cities such as Mohenjo Daro and Harappa, resulting in overcrowding and civic disorder. Without a tradition of army-enforced social integration, leaders had no mechanism for maintaining trade networks and controlling the movement of peoples as they spread out into new regions.

The Indus Culture Changes

THE SPEED OF CHANGE varied in different areas, but by 1300 to 1000 B.C.E. a new social order characterized by a distinctive ideology and language began to emerge in the northern Indus Valley and the Ganges River region to the east. According to ancient Indian literary records such as the Vedas and the Mahabharata and Ramayana epics, this area was populated by numerous competing polities practicing Vedic religion and speaking Indo-Aryan languages such as Sanskrit and its various dialects. Our information is hampered by the fact that most of the Indus settlements dating to this period either have been destroyed by later erosion or brick robbing or are covered by continuous inhabitation, which makes excavation impossible. Both Harappa and Mohenjo Daro supported later settlements dating to this time, but these levels have been badly disturbed.

Even though many features of elite Indus culture faded away, some aspects of its urbanism and the important craft technologies survived. Pottery, faience, and copper and bronze continued to be produced in the Indus region, although they were adapted to changing raw materials and social needs. Around 1700 B.C.E. came the first evidence for glass beads produced at Harappa, some 200 years before glass was being made in Egypt. During the subsequent Painted Gray Ware culture (1200 to 800 B.C.E.), glass bottles and bangles as well as beads were being fabricated at sites throughout northern India and Pakistan. It was then, too, that iron production—a new technology that spread throughout the northern Indus Valley and the Ganges River region—emerged. Although the peoples of Anatolia and West Asia smelted iron during this period, iron production in ancient India and Pakistan was a separate development unrelated to activities in the West.

Much of the Indus culture has yet to be investigated, but the results of recent work at sites such as Harappa are finally lifting the veil from an important civilization that has long been shrouded in mystery. SA

RANDY OLSON *Aurora Photos*; HARAPPA ARCHAEOLOGICAL RESEARCH PROJECT AND DEPARTMENT OF ARCHAEOLOGY AND MUSEUMS, GOVERNMENT OF PAKISTAN

MORE TO EXPLORE

Deciphering the Indus Script. Asko Parpola. Cambridge University Press, 1994.

Excavations at Harappa 1994–1995: New Perspectives on the Indus Script, Craft Activities, and City Organization. Richard H. Meadow and Jonathan Mark Kenoyer in *South Asian Archaeology 1995.* Edited by Bridget Allchin and F. Raymond Allchin. Oxford & IBH, New Delhi, 1997.

Origins of a Civilization: The Prehistory and Early Archaeology of South Asia. F. Raymond Allchin and Bridget Allchin. Viking Penguin, Delhi, 1997.

Trade and Technology of the Indus Valley: New Insights from Harappa, Pakistan. Jonathan Mark Kenoyer in *World Archaeology,* Vol. 29, No. 2, pages 262–280; October 1, 1997.

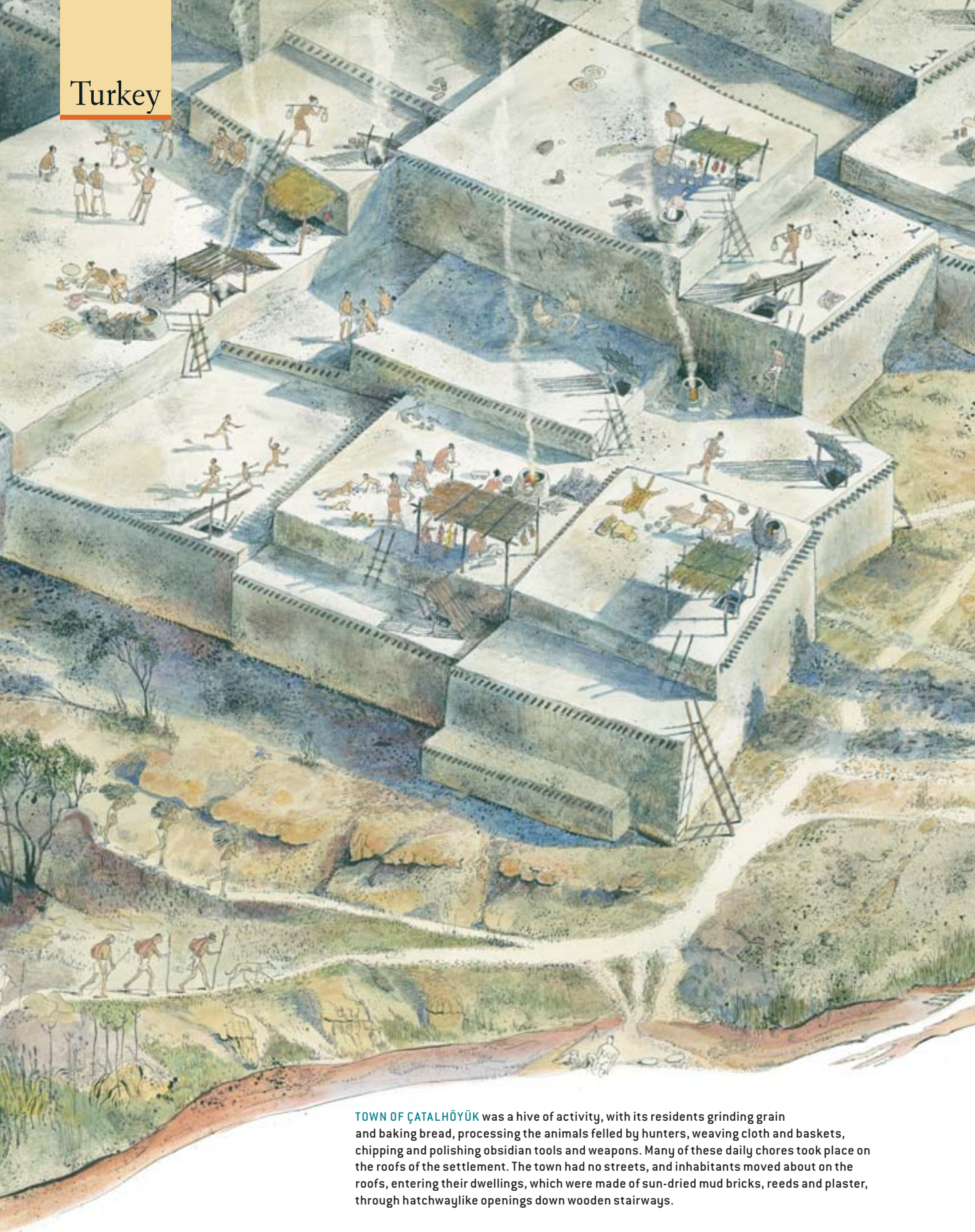
Ancient Cities of the Indus Valley Civilization. Jonathan Mark Kenoyer. Oxford University Press, Karachi, 1998.

The Indus Valley Mystery. Richard H. Meadow and Jonathan Mark Kenoyer in *Discovering Archaeology,* Vol. 2, No. 2, pages 38–43; April 2000.

For more information on Harappa, visit **www.harappa.com**

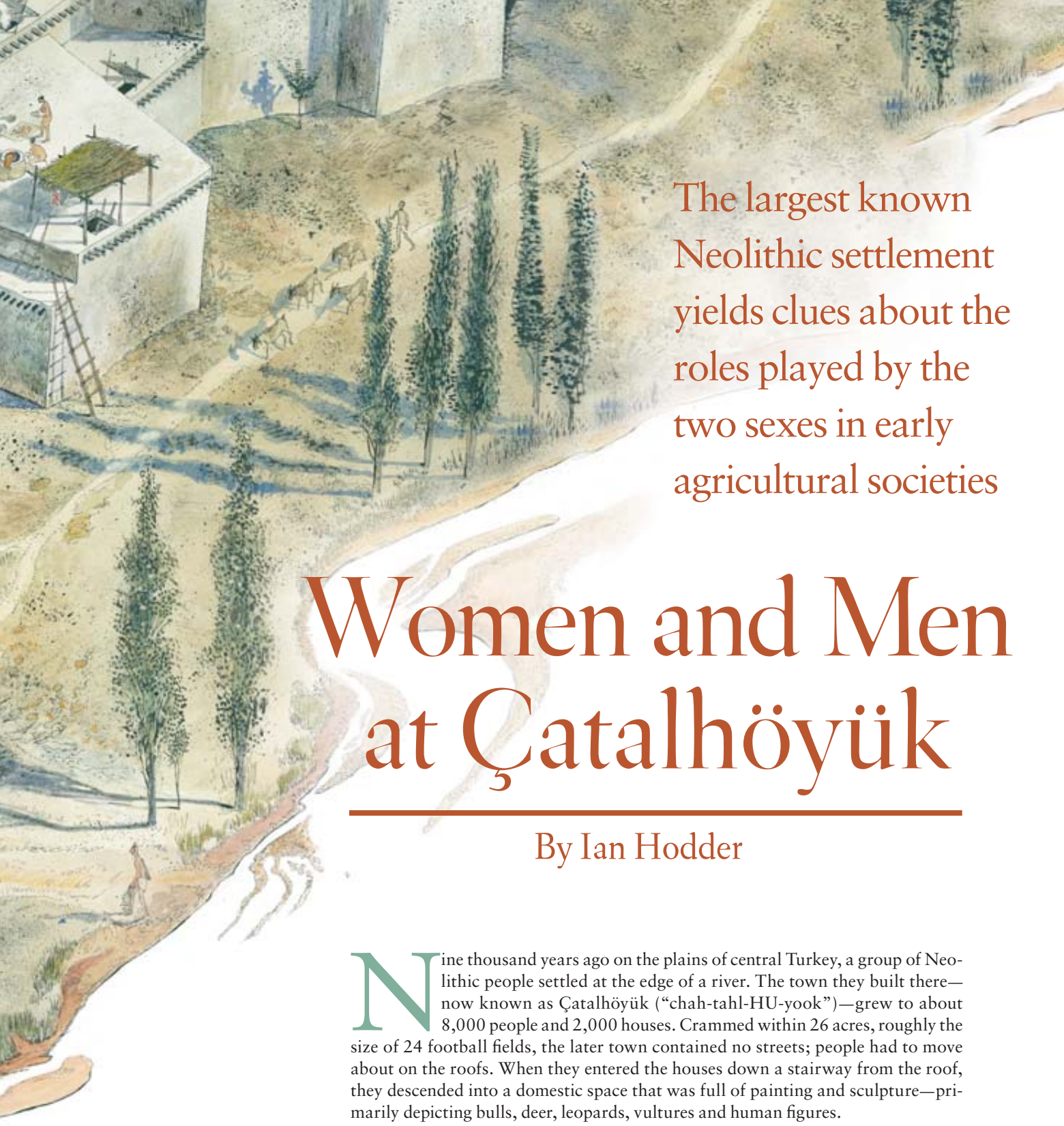
COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Turkey



TOWN OF ÇATALHÖYÜK was a hive of activity, with its residents grinding grain and baking bread, processing the animals felled by hunters, weaving cloth and baskets, chipping and polishing obsidian tools and weapons. Many of these daily chores took place on the roofs of the settlement. The town had no streets, and inhabitants moved about on the roofs, entering their dwellings, which were made of sun-dried mud bricks, reeds and plaster, through hatchwaylike openings down wooden stairways.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.



The largest known Neolithic settlement yields clues about the roles played by the two sexes in early agricultural societies

Women and Men at Çatalhöyük

By Ian Hodder

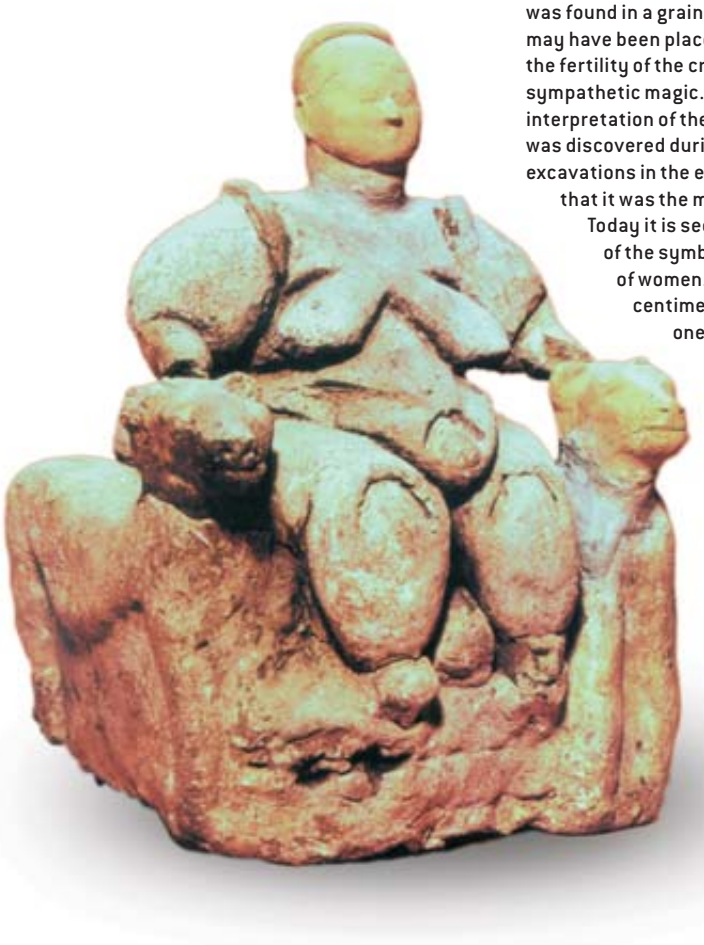
Nine thousand years ago on the plains of central Turkey, a group of Neolithic people settled at the edge of a river. The town they built there—now known as Çatalhöyük ("chah-tahl-HU-yook")—grew to about 8,000 people and 2,000 houses. Crammed within 26 acres, roughly the size of 24 football fields, the later town contained no streets; people had to move about on the roofs. When they entered the houses down a stairway from the roof, they descended into a domestic space that was full of painting and sculpture—primarily depicting bulls, deer, leopards, vultures and human figures.

These late Stone Age settlers had finely polished stone tools, and they had domesticated cereals and sheep. In addition, they hunted wild cattle, pigs and horses and made use of many wild plants. The site is not the earliest agricultural settlement, but its large size at an early date and its elaborate art mean that it has always played a part in discussions about early farmers and their way of life.

One of the questions in which Çatalhöyük was immediately embroiled was the role of women in early agricultural societies. A long tradition in European thought holds that most of these societies were matriarchies (women were the leaders, descent was through the female line, and inheritance passed from mother to daughters) and

JACK UNRUH

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.



CLAY STATUETTE of a voluptuous female figure supported by leopards was found in a grain bin, where it may have been placed to promote the fertility of the crops by sympathetic magic. The interpretation of the figure when it was discovered during the first excavations in the early 1960s was that it was the mother goddess. Today it is seen more in terms of the symbolic importance of women. At 16.5 centimeters high, it is one of the largest figures found at the site.

that they worshipped a powerful mother goddess. The idea of an agricultural phase in which the goddess was a potent symbol became a central tenet of the New Age goddess movements in the last decades of the 20th century, and many goddess tours have visited Çatalhöyük to pray, to hold circle dances and to feel the sway of the goddess.

Was Çatalhöyük the bastion of female power it has been thought to be? The resumption of excavations at the site in the 1990s, after a gap of a quarter of a century, has turned up fresh evidence of the relative power of the sexes at this place in central Turkey 9,000 years ago, and we can begin to answer this question—and to paint a picture of what it was like to be a woman or a man at Çatalhöyük.

The Mother Goddess

RESEARCH ON EARLIER and later agricultural sites provided some context for thinking about this question—and warned against expecting clear-cut answers. Before the 18th century, scholars in Europe had believed, based on Aristotle and interpretations of the Bible, that the political development of society began with patriarchy. During the 18th century, however, reports from North America told of societies that traced heritage through the female line, and in the early 19th century a Swiss jurist named Johann Bachofen argued that a phase of women's social power had preceded the patriarchal family. These ideas influenced many scholars in the second half of the 19th century and throughout the 20th century, including Sigmund Freud and archaeologists such as V. Gordon Childe and Jacques Cauvin.

The first excavator at Çatalhöyük was James Mellaart of the University of London, who, with his wife, Arlette, worked at the site from 1961 to 1965. He was steeped in the scholarship of the European tradition, so it is not surprising that when he discovered opulent female imagery, such as the figurine at the left, he presumed that it represented the mother goddess. The powerful naked woman sitting on a seat of felines (probably leopards), with her hands resting on their heads, seems to conjure up precisely the tamer of nature.

Mellaart's publications about the site, complete with images of potent women, reached a wide audience, but it was another archaeologist who most effectively took up the mother goddess view of Çatalhöyük. Marija Gimbutas of the University of California at Los Angeles in a number of publications, including her 1974 book *Gods and Goddesses of Old Europe,* argued forcefully for an early phase of matriarchal society, evident at Çatalhöyük but also found across Europe with the advance of agriculture. Patriarchal societies came later, she contended, in conjunction with metallurgy, horse riding and warring.

More recently, cultural anthropologists—who compare and analyze societies—have withdrawn from making such sweeping generalizations, because human groups living today or in the recent past offer a diverse picture of the roles of the two sexes. Furthermore, cultural anthropology provides no substantiated claims for true matriarchies. The record does show, however, that in most recent

Overview/*Life circa 7000 B.C.E.*

- A 9,000-year-old site at Çatalhöyük in Turkey reveals a curious town of thousands of houses crammed together with no streets between them.
- Inhabitants climbed down stairways from the roof to enter dwellings filled with wall paintings and sculptures.
- The lives of men and women in the town do not appear to have differed greatly. One or the other sex may have exercised more power in certain spheres—men in hunting, women in growing plants, for example—over various periods in the town's history, but both sexes played key roles in social and religious life.

JAMES MELLAART

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

and contemporary societies women have some form of authority or that women at certain stages in their lives, or in certain contexts, have power. Rather than talking simplistically about matriarchies and patriarchies, we should expect, according to the ethnographic evidence, a more complicated picture, which is just what we find at Çatalhöyük.

You Are What You Eat

SO FAR EXCAVATIONS at Çatalhöyük have extended over only 4 percent of the site. We have discovered 18 levels of habitation (each built on top of the previous level), covering a total of about 1,200 years. Most of our understanding comes from the middle and earlier levels, which have been examined most closely.

Some of our strongest scientific evidence about the relative status of men and women in the early and middle levels of Çatalhöyük concerns diet. If women and men lived notably different lives, and if one or the other was dominant, then we might expect to uncover disparities in diet, with the dominant group having more access to certain foods, such as meat or better joints of meat. So we have searched hard for such evidence, but we have not uncovered clear differences.

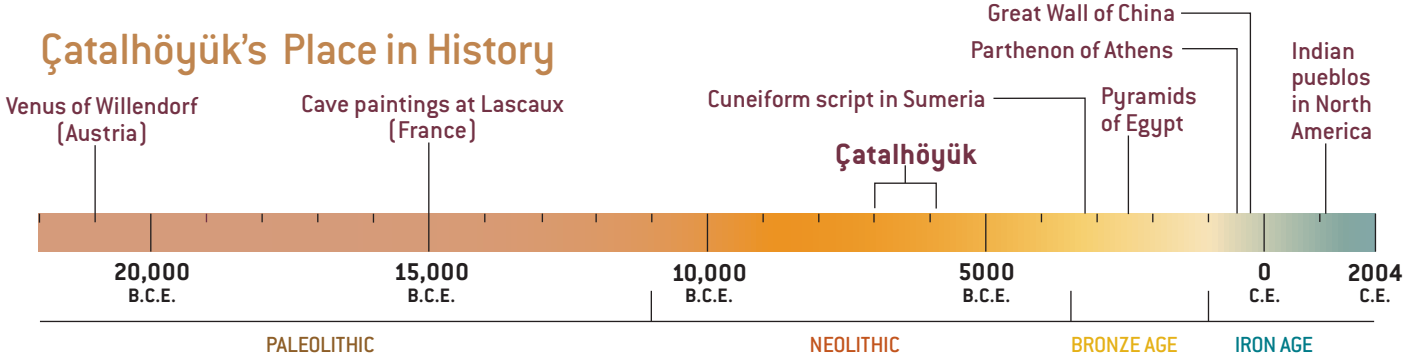
Two of my colleagues, Michael P. Richards of the University of Bradford in England and Jessica A. Pearson, now at the University of Liverpool, have analyzed the stable isotopes in ancient bones at Çatalhöyük to discover what people ate. The inhabitants of the settlement buried their dead underneath the floors of the houses, and in one building we found 62 bodies. The analysis of these skeletons detected no statistical variation between the isotopes in male and female bones. The same is true of the teeth, which were studied by Basak Boz, a graduate student at Hacettepe University in Ankara, in collaboration with Peter Andrews and Theya Molleson of the Natural History Museum in London. Women tend to have more cavities than men, but in terms of wear on the teeth the researchers found no difference.

By analyzing the patterns of wear and tear on the bones, Molleson has also been able to demonstrate that the people seem to have carried out very similar tasks during their lives [see "The Eloquent Bones of Abu Hureyra," by Theya Molleson; SCIENTIFIC AMERICAN, August 1994]. An intriguing piece of evidence supports this finding. Andrews and Molleson had noticed a black deposit often lining the inside of the ribs, which when analyzed proved to include carbon. The inhabitants of Çatalhöyük lived in small houses with little draft and with much smoke from the fire. Indeed, the wall plasters were covered with soot. The same soot got into people's lungs.

The hole in the roof through which inhabitants entered their houses was also where the smoke from the fire came out. Winters in the area are extremely cold, so families may have spent a great deal of time indoors, breathing smoky air. As a result, soot built up in their lungs. After burial and during the decay of the body, the soot was deposited on the inside of the ribs. But—and this is the crucial point for our purposes—both men and women had soot on their ribs. This finding implies that we cannot argue, for example, that men had more of an outdoor and women more of an indoor life. In fact, they appear to have lived quite similar lives in terms of the amount of time spent in the house.

ÇATALHÖYÜK originally lay beside a river and was surrounded by marshland. Today the river has dried up, and the area, 3,000 feet above sea level on the Anatolian plateau, is covered by fertile wheat fields.

Çatalhöyük's Place in History



NINA FINKEL

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

At Home in the Stone Age

IN 1958 ARCHAEOLOGISTS DISCOVERED a late Stone Age settlement on a mound rising out of the plain in central Turkey. To their surprise, the site, which dated back to 7000 B.C.E., turned out to be far more than a village; it could rightfully be called a town. Çatalhöyük ("forked mound") had been a community of several thousand inhabitants who had an impressive social organization, a rich religious life, a high level of technology (weaving, pottery, obsidian tools), and a genius for painting and sculpture.

Researchers eventually identified 18 superimposed building levels on the 26-acre site. The habit of building one structure on top of another, using the old walls as foundations, led to a certain uniformity of plan. But by subdividing rooms or joining others together and by creating an open space in place of one or more rooms, the builders managed to vary the plans of individual levels considerably, and pleasant irregularities break the monotony of row after row of dwellings.

Nevertheless, orderliness and planning prevail: in the standard layout of houses, in the size of bricks, in the heights of panels, doorways, hearths and ovens, even in the size of rooms. The houses themselves range in size from about 11 to 48 square meters, but they are invariably rectangular. Constructed of timber frames, sun-dried mud bricks, reeds and plaster, all the buildings appear to have been only one story high. Bundles of reeds formed the flat roofs, with a thick mud cover on top and a mat below to prevent bits of reeds from falling on the inhabitants.

Entry through the roof is one of the most characteristic features of the buildings; other access was rare. Each house had a wooden stairway made of squared timber, one side of which rested along the south wall, where it has left an easily recognizable diagonal mark in the plaster. The stairs descended from a hole in the roof, and through this same opening the smoke from the hearth, oven and lamps escaped. Movable ladders provided access to the roofs from outside the town. The interiors were rich in sculptures and wall paintings—the first paintings ever found on constructed walls. The main room served as the area for cooking, eating, sleeping and many other activities. The kitchen was always along the south side, to allow smoke to escape through the entrance hole in the roof. Secondary rooms, used for storage, were entered from the main room through low doorways; one could move through them only by squatting or crawling.

Along the walls of the main room were built-in, raised platforms for sitting, working and sleeping. These were as carefully plastered as the rest of the dwelling, and they were often covered with reed or rush matting as a base for cushions, textiles and bedding. No single building provided sleeping space for more than eight people, and in most cases the family was probably smaller. Below these platforms the dead lay buried. The bodies were tightly wrapped in a crouched position and often placed in baskets.

So far no wells have been discovered. But some buildings had toilet areas; the material was taken out and put in disposal heaps used for both sanitation and rubbish. The thick ash deposits in these heaps made efficient sterilizers. Houses were kept scrupulously clean; remains of meals such as broken bones are a rarity in any building.

Nothing suggests that defense was the reason for the peculiar way in which the people of Çatalhöyük constructed dwellings with sole entry through the roof. Nor is there evidence of any sack or massacre during the 1,200 years of the town's existence so far explored. At present, the most likely explanation for the close huddling of houses is that people wanted to be buried on or near their ancestors. As nearby spaces for building new dwellings disappeared, the cramming in of houses meant that the only access possible was from the roof. What caused the final abandonment of the settlement is still far from clear.

ARCHAEOLOGISTS working at Çatalhöyük have reconstructed a typical house. They plastered the internal walls and the built-in furniture and then smoothed them with rubbing stones. Then they experimented with pigment mixes to replicate wall paintings. Using both dung and various kinds of wood, the researchers lit the oven and analyzed the residue to see how it compared with the archaeological remains of burned fuel. The house has provided insight into the use and feel of the interior space and raised many questions about light sources and problems of air circulation when the ovens were in use.

ÇATALHÖYÜK RESEARCH PROJECT

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

The study of the human remains showed that men were taller than women, but the variation in size was slight. The bones reveal that women were sometimes fatter in relation to their height than men. So perhaps there is some truth to the images of "fat ladies" seen in the figurines discovered by Mellaart. But overall, various lines of evidence suggest similar diets and lifestyles for women and men. We see little indication that the sexes had specialized tasks or that daily life was highly gendered.

This is not to argue that differences based on sex did not exist. An obvious one relates to childbirth. Study of the human bones has shown a high rate of infant and child mortality and several cases of burials of women with babies, perhaps indicating death during childbirth. But dietary and bone analyses give no clear sign that any divergence in lifestyle between women and men was translated into differences of status or power.

In Life and in Death

WE SOUGHT MORE information on status by looking into a custom at Çatalhöyük that seems bizarre from a 21st-century perspective. Archaeologists have excavated burials of headless bodies at the site. Most people were buried with their heads intact, and they were left like that. But in some cases, perhaps a year or so after burial, the grave was reopened and the head was cut off with a knife, leaving cut marks on the bones. These heads were then used for ceremonial purposes. They were sometimes later left as part of abandonment rituals in houses. These practices are part of a wider tradition among the early farmers of Turkey and the Near East. At such places as Jericho, the skulls were plastered to re-create human features of the face.

It appears likely that the heads were removed from notable individuals—perhaps literally family or lineage "heads." So it was of great interest to find that the skulls of both men and women were circulated and curated, thus suggesting that lineage or family could be traced through both female and male lines.

We reach a similar conclusion when we consider another aspect of burial. The 62 burials in one building that I mentioned earlier largely occurred below platforms and spaces around the edges of the main room. A particular platform would serve for a time for burial and then go out of use. It is possible that the death of a particular person, specifically the last one buried in a spot, influenced when the shift in use took place—and these last-buried individuals are both male and female.

Archaeologists are accustomed to studying the layout of graves and of the artifacts in them to assess social distinctions. We have looked carefully to see whether men are always buried in one part of the room and women in another, whether men are buried on their left side and women on their right, whether men face one direction and women another, whether certain artifacts are found in the graves of men and others in the graves of women. Naomi Hamilton, while a postgraduate student at the University of Edinburgh, searched for such patterning. Look as she might, she could not tease out any clear distinctions. In one way, this is very frustrating, but in other ways, it is fascinating. It suggests a society in which sex is relatively unimportant in assigning social roles.

The burials imply equality, but what about the use of space within the houses during life? Archaeologists have often argued, on the basis of much contemporary study of small-scale, non-Western societies, that men would have made the stone tools, whereas women would have made the pots and done much of the cooking. The trouble with such assumptions is that one can always find ethnographic examples in which the roles are reversed. But let us for the moment allow that some sexual division of labor may have existed at Çatalhöyük when it came to activities inside the house. Each domicile contains a hearth or oven.

BODIES of family members, such as this nine-month-old child, were usually laid on one side, often placed in a basket or on a reed mat and then buried under the floors and sleeping platforms of the dwellings. The lime plaster floors above the burials and the smoke from the ovens may have masked the odor of decay.

Around the oven we find large accumulations of ashy rake-out material from the fire as well as the remains of cooking and processing cereals. So, we might conclude, the area around the oven was for food processing, and it was mainly the domain of women. One piece of evidence could be taken to support such a view: neonate burials frequently occur near the ovens.

But the ashy rake-outs also contain high densities of obsidian that had been flaked and knapped to make stone tools. The obsidian was traded from Cappadocia in central Turkey and then placed beneath the floor near the oven until pieces were taken out and made into tools. Such trading and tool production are often the province of men. If this was so at Çatalhöyük, then forming the obsidian into tools does not seem to have taken place in an area separate from that linked to domestic activity. Whether

THE AUTHOR

IAN HODDER received his doctorate from the University of Cambridge and was professor of archaeology there from 1977 to 1999, when he moved to Stanford University. He is chair of the department of cultural and social anthropology at Stanford and project director of archaeological research and excavation efforts at Çatalhöyük in Turkey. His books include *Symbols in Action* (1982), *The Present Past* (1982), *Reading the Past* (1986), *The Domestication of Europe* (1990), *Theory and Practice in Archaeology* (1992) and *The Archaeological Process* (1999).

ÇATALHÖYÜK RESEARCH PROJECT

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

men or women made the stone tools, we find no indication of a clear separation of roles and tasks in any of the levels that have been excavated to date.

Life Is Short, Art Is Long

THE PICTURE LOOKS quite coherent thus far. When we examine how people lived their daily lives—what they ate, what they did, where they were buried, who was paramount in terms of lineage and family—we see little in the way of radical division between men and women, no evidence for either patriarchy or matriarchy.

But in the world of symbolic representation and art, we see something quite different. Here the realms of influence seem distinct. Consider first the males of the community. The abundant paintings appear to concentrate on men. By and large, the paintings do not portray women, whereas they include many figures of men, often clad in leopard skins, hunting or teasing wild animals. In some panels, these images are unmistakably men because they are bearded.

Indeed, much of the art is very masculine, and much is concerned with wild animals, a number of them male—bulls and stags with erect penises, for example. The numerous animal heads fixed to walls of the houses are mostly those of wild bulls and rams. This male focus of the art has a long tradition in Anatolia. Excavations at the earlier site of Göbekli in southeastern Turkey have found fantastic images of wild animals, often with erect penises, as well as stone phalluses around the site.

Nerissa Russell of Cornell University and Louise Martin of University College London have identified concentrations of the bones of large wild animals—mainly bulls—at Çatalhöyük. These deposits, which contain higher proportions of bull bones than do those from daily meals, seem to be the residues from special feasts. The many paintings depicting groups of men and bulls could well commemorate such feasts or other rituals, as could the heads of bulls and other wild animals that were installed in the houses and plastered and painted.

As we have seen, however, the isotopic analysis of the human remains indicates no differences in the diets of the sexes, leading us to conclude that women as well as men participated in eating at these events. Only in the art connected with hunting and feasting do we see a distinction.

And what of the powerful female figure on the seat of leopards? Surely that indicates a strong image of women. Moreover, a recent find at Çatalhöyük reinforces this presumption: we discovered an intriguing female figurine that has a wild seed lodged in its back [*see illustration below*]. This connection between women and plants is also evident in the place that the famous "goddess" with leopards was found: a grain bin. And the few paintings that unmistakably depict women appear to show them gathering plants.

But aside from these few examples, the art and symbolism on the whole downplay or even deny the significance of agriculture. The houses are filled with symbolic representation: in many dwellings, one seems hardly able to move without facing some bull's head or painting. Yet in all this, the grain stores are never elaborated with any form of symbolism. The domestic pots are not painted or decorated; neither are the baskets used to store grains. The entire area of plants and agriculture is marginal in the art and symbolism. The artistic evidence, then, points to a divided world, one dominated by males and their activities involving hunting and wild animals and the other, less frequently portrayed world involving women and plants.

The situation is of course more complicated than this simple division implies. We must consider, too, the evolution of this society as it is revealed in the various levels of occupation. The figurines of fat ladies, and especially the woman on leopards found in a grain bin, as well as the woman with a grain lodged in her back, come from the upper

RECENT FINDING of a female figurine, only 2.8 centimeters high, with a seed embedded in her back suggests the important role women played in the nascent domestication of plants at Çatalhöyük.

ÇATALHÖYÜK RESEARCH PROJECT

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

PAINTING of an enormous red bull (the now extinct aurochs, *Bos primigenius*) occupied the wall of one house. The bull itself is more than six feet long, and the disproportionately small size of the male figures that surround it suggests the awe that the creature inspired. The painting may commemorate a feast or other ritual.

levels of the site—specifically, the most recent three or four in the total of 18. Although agriculture and domesticated plants had existed for centuries, key aspects of social life, as revealed in the art and in the remains of feasts, continued to focus on wild animals. In the upper levels of Çatalhöyük, however, we may be observing agricultural products becoming more central to the life of the community, with rituals taking place that involved farming. We also see in the art, particularly in the figurines, women linked to the growing of plants.

This prominence of agriculture and the role women play in it is part of a wider set of changes that occur in the upper levels of the site. In particular, we find large-scale ovens outside the houses, in courtyards, which may indicate some specialization in food production. Certainly the specialization in the manufacture of stone tools and pottery increases in these upper levels. And stamp seals appear, suggesting a greater sense of ownership. It is in this overall context that we see gender divisions becoming more marked and a specific female domain—growing plants for food—becoming more manifest.

So the picture of women and men at Çatalhöyük is complex—in a way that echoes some of the conclusions I mentioned earlier that anthropologists have reached about the allocation of power between the sexes. We are not witnessing a patriarchy or a matriarchy. What we are seeing is perhaps more interesting—a society in which, in many areas, the question of whether you were a man or a woman did not determine the life you could lead.

Both men and women could carry out a series of roles and enjoy a range of positions, from making tools to grinding grain and baking to heading a household. The depictions of feasting rituals imply that men dominated in this realm. But we can discern no sign that they had an overarching influence on other areas of life. And in any case, such male dominance came to be contested when, several millennia after the domestication of cereals, plant agriculture began to play a fuller part in the life of the community.

At this point, women and plants are linked in the art, but even here, whether the dominance of women in agriculture had much effect on other aspects of life must await further scientific study. In particular, we have much less information from the upper levels, where we found the fat ladies and the large-scale ovens, than we do from the earlier levels, where we have analyzed bones and teeth. Only when excavation of the upper levels is renewed over the next five years will we be able to see how this story of the emergence of images of powerful women unfolds. SA

MORE TO EXPLORE

A Neolithic City in Turkey. James Mellaart in *Scientific American,* Vol. 210, No. 4, pages 94–104; April 1964.

Çatal Hüyük: A Neolithic Town in Anatolia. James Mellaart. McGraw-Hill, 1967.

On the Surface: Çatalhöyük 1993–95. Edited by Ian Hodder. Cambridge: McDonald Institute for Archaeological Research and British Institute of Archaeology at Ankara, 1996. ISBN 0951942034.

Why Settle Down? The Mystery of Communities. Michael Balter in *Science,* Vol. 282, pages 1442–1445; November 20, 1998.

A Tale of Two Archaeologists. Robert Kunzig in *Discover,* Vol. 20, No. 5, pages 84–92; May 1999.

More information can be found online at **www.catalhoyuk.org, catal.arch.cam.ac.uk/catal/**

JAMES MELLAART

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

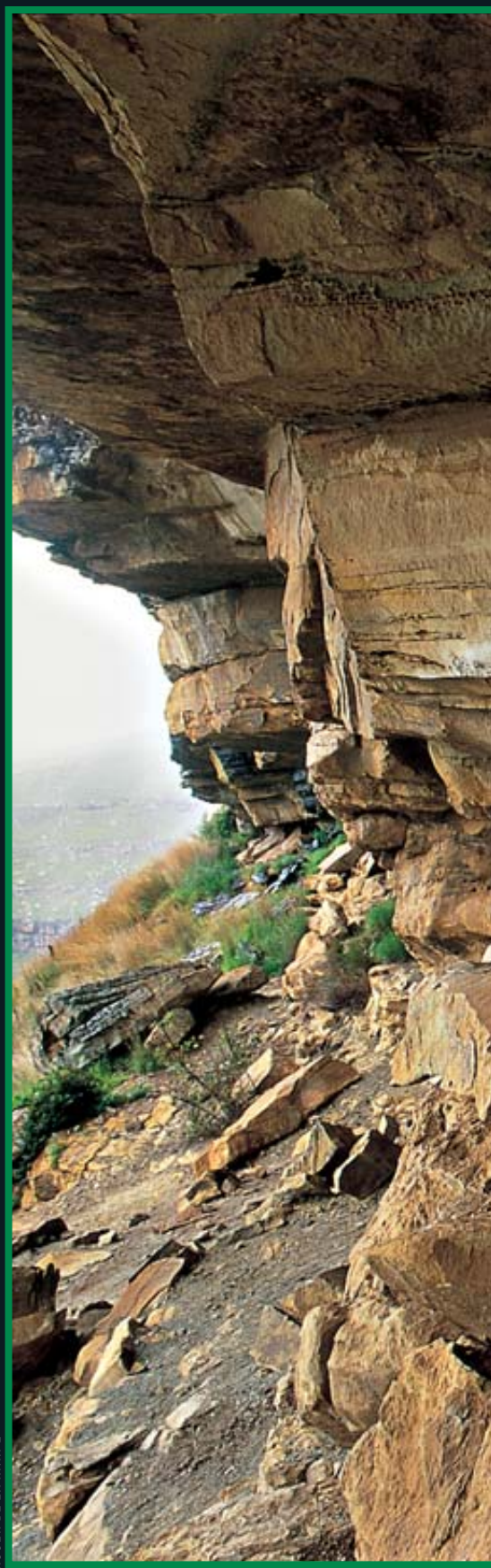
Rock Art in Southern Africa

Paintings and engravings made by ancestors of the San peoples encode the history and culture of a society thousands of years old

By Anne Solomon

For more than three hours, a colleague and I walked through the grassy foothills of the Drakensberg Mountains in KwaZulu-Natal, meeting not a soul on the way. Ultimately, we came to a wide cave half-screened by bushes and a splashing waterfall. Behind this watery veil are some of the finest specimens of ancient San, or "Bushman," rock painting in South Africa. The water has not damaged them, although vandals have. We gazed at walls covered with more than 1,600 images of humans and animals engaged in myriad activities. That night, we slept in the cave, continuing our trip the next day.

That expedition, 10 years ago, was to obtain paint samples that might be radiocarbon-dated. One sample, from a painting of an eland (the biggest of all antelopes), contained microscopic quantities of organic material that allowed the image to be dated to about 400 years ago. Such a direct measurement is rare. Most pieces of rock art, painted in red, brown or yellow ocher—a hydrous iron oxide—contain no organic carbon. So radiocarbon dating, which measures the steady decline of the isotope carbon 14 in organic materials, cannot be used. Our earliest date comes from a Namibian cave, where excavated floors contained painted slabs between 19,000 and 26,000 years old. The oldest date we have for painting on cave walls indicates that mural art was being made at least 3,600 years ago.



ROGER DE LA HARPE

PAINTING of elands and humans (*right*) in Kamberg Nature Reserve in KwaZulu-Natal.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Rock paintings and engravings, testimony to a once ubiquitous hunter-gatherer presence, are found from coast to coast in thousands of diverse sites in southern Africa. Some sites are sheltering sandstone caves with hundreds of images; others contain only one or two figures. Some paintings look exquisite, their lines and colors still fresh. Others are faint and crumbling, damaged by time, water and the graffiti of unthinking visitors.

By far the most common subjects in rock art are humans—usually shown in profile, sometimes unclothed—and a wide variety of animals. The most revered of the animals are the larger herbivores. The eland is widely celebrated, although different areas have their own favorites: the elephant in South Africa's Cape Province, for example, and a species of antelope called kudu in Zimbabwe. A variety of other creatures are also pictured. Snakes, lions and fish are not uncommon in the art of the Drakensberg Mountains. Hippopotamuses, rhinoceroses, rhebok, baboons, ostriches and domesticated animals appear in the art of many areas. Rarer themes include the aardwolf, aardvark and other creatures both real and imaginary. With the exception of snakes and bees, the San people rarely painted reptiles and insects.

Rock art research is among the most demanding of archaeology's subdisciplines. Without recourse to conventional archaeological methods—weighing, measuring, mapping and statistical comparison—rock art research relies on theoretically and culturally informed interpretations, supported by particularly rigorous argument. We do know that the artists were among the earliest inhabitants of southern Africa, the ancestors of the modern-day San peoples. The term "San" is a linguistic label: the San and Khoekhoe—formerly Hottentot—languages make up the Khoisan group of many related languages and dialects, characterized by click sounds. The plant-gathering and hunting economy of the San has been extensively studied as a model for how people lived until relatively recent times, when animals and plants were domesticated.

ROCK ART is found all over southern Africa. Its range attests to the vast areas once occupied by the ancient San. (Except as noted, all the paintings that follow are from KwaZulu-Natal.)

LUCY READING-IKKANDA

Although rock art occasionally provides historical information, paintings and petroglyphs are not historical documents. It is only after the 15th century, when Europeans "discovered" southern Africa, that we begin to have a clearer picture of historical conditions. In 1652 the Dutch established the first permanent settlement in Cape Town. As the newcomers expanded their domain over the next three centuries, they frequently displaced indigenous peoples, whose traditional ways of life changed or disappeared entirely. In some areas, theft of cattle and horses by the San led to retaliatory raids by European farmers. Episodes are recorded in which entire San groups were massacred. Survivors of these communities were eventually absorbed into indigenous herding and farming societies or became laborers around European settlements.

The ancient art traditions had ceased by the 20th century. Today relatively few San speakers live in the old ways, except in parts of Botswana and Namibia. Only the wide distribution of archaeological sites, place-names and rock art alerts us to the vast areas once occupied by these peoples.

In studying the art, the archaeologist is forced to seek all imaginable clues. There are two classes of work: the paintings, which usually occur in caves and shallow shelters, and incised boulders and other surfaces that are found in the dry interior. The petroglyphs, which tend to be less figurative, have until recently attracted less attention than the paintings.

The style and, to a lesser extent, the subject matter of the paintings vary between regions. Often a single site includes works in several styles, so that it is impossible to tell whether it is the work of different artists or art from different historical periods. Early researchers suggested that simpler or less delicate images, in one color only, are the oldest, with color range and stylistic intricacy evolving through time. To-

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Dancing into the Night

DANCING, accompanied by clapping and singing in melodic overtones, is an integral part of San life. Women may dance alone, as in the painting above; a few are depicted with leather "aprons" that are still occasionally worn. The detail (*below right*) from another painting of a dance probably depicts a female initiation ceremony. The /Kung San family is celebrating a successful hunt in the Kalahari by dancing into the night (*above right*). Note the white ostrich-eggshell knee bracelets on the woman at the bottom left; they resemble the white-dot decorations on the painted figures (*above*).

ANNE SOLOMON (*rock paintings*); ANTHONY BANNISTER (*celebration*)

day we know there is no such straightforward correlation. Some of the less accomplished work is probably the most recent—some perhaps made by shepherds and children.

Devotees have been trying to interpret rock art for more than a century. Those interpretations change with new knowledge, discoveries and intellectual currents. San testimonies would be extremely helpful in guiding us, but unfortunately, only one exists. It came from a Lesotho San man named Qing, who acted as a guide to a British official, Joseph Orpen, in the Lesotho Mountains in 1873. Qing was familiar with the making of rock paintings and commented on the paintings that they saw. Qing confirmed what some already suspected: that rock painting, as one contemporary European scholar wrote, was not "the mere daubing of figures for idle pastime" but "a truly artistic conception of the ideas which most deeply moved the Bushman mind."

In addition to Qing's direct testimony, researchers also draw on indirect accounts from San speakers. By far the richest body of material was collected a century ago, from people speaking a San language known as /Xam (the initial character is a click sound). In 1870 a group of /Xam San men from northern Cape Province were imprisoned in Cape Town for offenses ranging from stock theft to murder. Wilhelm H. I. Bleek, a German philologist, acquired custody of the men, who built huts at the bottom of his garden and worked as domestic servants. But their main task was sharing accounts of their traditions. While Bleek focused on the language, his sister-in-law, Lucy C. Lloyd, recorded thousands of pages of /Xam lore. A selection was published in *Specimens of Bushman Folklore,* written by W.H.I. Bleek and L. C. Lloyd (George Allen, London, 1911).

This extraordinary colonial encounter revealed the /Xam world: personal histories, myths, religious beliefs, and magical and mundane practices. Although by the late 19th century these people no longer practiced rock art, their commentaries have proved extremely valuable for interpreting it. Together with Qing's account, the /Xam testimonies have helped show that African rock art is much more than mere decoration or reflections of everyday concerns. Instead rock art can best be understood as a religious art, reflecting the /Xam people's relations with the spirit world and to ritual practices. And almost certainly the act of painting itself had magical importance.

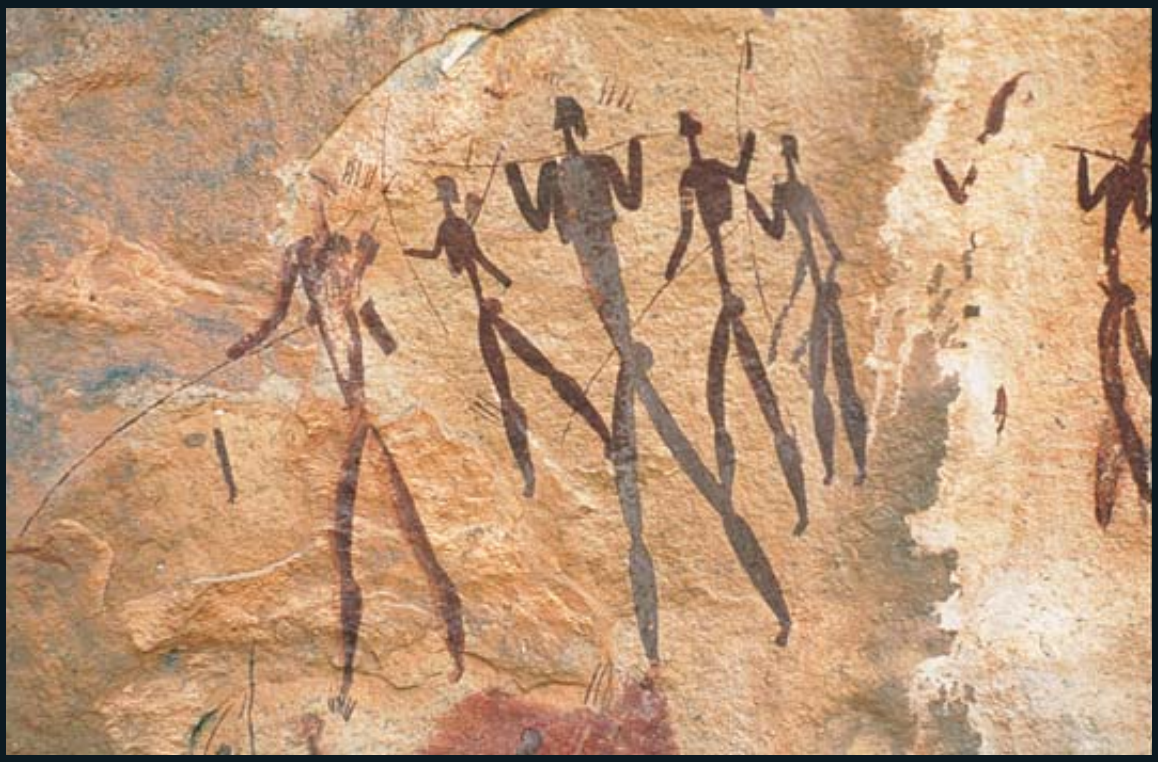
A comparison of Qing's account with the /Xam testimonies shows broad simi-

THE AUTHOR

ANNE SOLOMON is a graduate of the University of Cape Town, where she obtained her Ph.D. She is a former postdoctoral research fellow of the Getty Center for the History of Art and the Humanities in Los Angeles and was, until recently, senior curator of archaeology at the Natal Museum in Pietermaritzburg. Her book on San arts, *The Imagination of the San,* is to be published in early 2005 by the University of KwaZulu-Natal Press.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Long Limbs, Weird Faces



HUMANS are represented in varying styles. The men carrying quivers of arrows on their backs shown here (*left*) are exceedingly tall and thin, whereas the women are voluptuous (*center*). The clothed figures (*far right*), wearing leather cloaks known as karosses, have strange concave faces.

THERIANTHROPE (a half-animal, half-human figure) derives from San religious tradition. In the beginning, animals were humans; only after a creation event were they differentiated. This creature seems to be carrying a smaller antelope on its back.

larities between /Xam and Lesotho San myths. Both San peoples esteemed a creator figure named /Kaggen. Both also spoke of underwater beings and of the creation of the eland. Qing supplied the long-sought link between rock art and myth, whereas the /Xam accounts provided crucial cultural detail that Qing's commentary lacked. Researchers since have relied heavily on both sources.

Window on Culture

SEVERAL SCHOLARS have noted the extraordinary similarities between the mythology of San groups far distant from one another in time and space. All San peoples tell of a primeval time when animals were people; after an initial creation event, they were differentiated. But these first people were often stupid, lacking customs and manners, and only after a second creation did they become real people.

Many stories recount the doings of these animal people. Some explain the origins of fire, heavenly bodies and other physical phenomena. We hear why the baboon has a hairless rump, why people marry and why death is inevitable. Other narrative themes include encounters with warlike neighbors or dangerous carnivores. Food is a constant preoccupation, with a surprising number of stories featuring autophagy—the eating of one's own body. The stories dramatize the dilemmas of existence that faced San hunter-gatherers and emphasize themes involving death and regeneration.

The belief that animals were once people allows an interpretation of therianthropes—figures both human and animal. Some of these paintings, and others of fantastic creatures, may portray beings from the primordial world. Alternatively, some researchers contend that they depict the shaman's experience of physical transformation during a trance—when shamans enter the realm of the spirits of the dead.

Some experts, notably David Lewis-Williams and his colleagues at the University of the Witwatersrand, Johannesburg, have correctly observed that the art does not illustrate the mythology. They propose instead that rock art

ANNE SOLOMON

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

is connected to ritual—and to one ritual in particular: a healing dance that is still practiced by communities in Botswana and Namibia (these peoples do not make rock art). During a ritual dance that may last all night, shamans enter an altered state of consciousness induced by rhythmic movement, singing and clapping. In this hallucinatory state, they believe that they travel to the spirit realm to battle supernatural forces that cause illness.

Lewis-Williams and his associates have proposed that shamanic hallucinations may have prompted the first making of art, in Africa and elsewhere. They hypothesize that because humans all share the same neurological circuitry, visual hallucinatory forms should be similar throughout time—and that geometric designs drawn in the European Paleolithic and Bronze ages, as well as North American Indian art, may also be understood in terms of the healing trance dance and shamanic hallucinatory experiences.

It is certainly true that many creatures in San mythology are not portrayed in the rock art. Yet mythology does provide a crucial context for understanding ritual. Myths tell of the origin of death and disease, the trials of life that ritual practices address. Art-making can probably best be seen as being linked to ritual practices—such as rainmaking and initiation—recorded from recent San peoples.

Rainmakers

RECENT STUDIES have shown that hunting scenes in rock art are not as common as early researchers believed. Some paintings originally thought to depict hunts almost certainly portray rainmaking. Testimonies from the /Xam show that they viewed the rain cloud as an animal walking the countryside on "legs" of streaming rain. Rainmakers had to lead a large herbivore from its home in a water hole, take it to a high place and slaughter it; where its blood ran, rain would fall. The rain animals depicted in rock art resemble large herbivores, such as cattle, hippos or antelopes, but often with strange features and proportions. The rain bull in myths and stories embodied the lethal thunderstorm, whereas the female rain animals brought gentle rain.

Qing, in Lesotho, also described rainmaking. He described one rock painting as depicting underwater beings who tamed "eland and snakes." This painting shows six humanlike figures and two bristly animals of no known species, one led by a thong attached to its nose, the other being approached by two men with spears. Despite their geographic separation, both Qing and the /Xam described markedly similar beliefs regarding rain.

Some have argued that rainmakers depicted in such paintings were living shamans, but there is ample evidence that they were in fact considered to be benevolent spirits—dead family members who helped their living kin. Qing, for example, described antelope-headed men in rock paintings as "men who had died and now lived in rivers." These men, as well as the underwater beings leading the rain animals, can best be interpreted as spirits of the dead. /Xam commentators specifically stated that

ANNE SOLOMON

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

"sorcerers of rain" were dead people, as were "game sorcerers" to whom the living would appeal for help in the quest for food.

Understanding San beliefs about rain is crucial to understanding their art. Like Kalahari peoples today, the San told of two important beings, a creator figure and a master of death and disease. In the /Xam narratives, this death deity is the Rain Bull. He is the dangerous thunderstorm and the water in the waterhole. People became stars after they died, which then fell into the water where the Rain Bull lived. Qing's accounts of dead people living underwater derive from this same complex of beliefs.

Clearly, rock art images of people catching a rain animal allude to more than just controlling the weather. As master of the spirit world, the Rain Bull controls not just rain but also life and death, sickness and health. The "rain paintings" common in rock art can therefore be linked to people's efforts to prevent disease and misfortune and not just storms or drought.

Importance of Initiation

HUNTER-GATHERER societies such as the San are egalitarian, with both sexes having equal access to resources. Nevertheless, social distinctions do exist, and the two most important in these societies—gender and age—meet in the institution of initiation. Ceremonies for girls at puberty, copiously documented, seem to eclipse male initiation, which seems at most to have been a lesser celebration of a boy's first kill. Contemporary Kalahari hunter-gatherers also have conspicuous female initiations. Numerous /Xam stories tell of female initiates who disobeyed the puberty seclusion rules, sneaked off, and were then abducted and drowned by the Rain Bull. (After entering the cultural repertoire, the Rain Bull and other visual images may have been used in varied contexts for different purposes. Initiation paintings, for example, do not seem to involve interactions with the spirit world.)

/Xam initiation stories tell of the dangers attractive female initiates posed to men. The purpose of the rites, however, was probably equally to protect young women from inappropriate male attention. In the close proximity of band societies, members are highly dependent on social cooperation and harmony. Tensions between kin arising from sexual jealousies and misdemeanors may be socially and economically destructive. A purpose of initiation was surely to regulate interpersonal behavior and avoid such conflicts.

Though not abundant, some rock art sites and compositions may have been part of gender-specific initiation rites. Hugely voluptuous female figures with genital details, brandishing crescent-shaped objects, may well relate to female initiation. Paintings of women's dances may be linked to initiation or birth. A remote shelter high in the southwestern Cape Province mountains—unusual for its abundance of female figures and total absence of male imagery—may also pertain to female initiation or birth. Another composition apparently depicting a female initiation ceremony is found in a KwaZulu-Natal Drakensberg site. It shows a prone figure and three clapping women in a circular enclosure. Other figures dance outside. On the periphery of the composition (not shown in the illustration) is a male figure with considerably overemphasized genitalia.

PROBABLE RAIN CEREMONY, showing an animal being captured by rainmakers (*top*), is painted in red ocher. The eland (*bottom*) is the southern San creator's favorite animal—and, along with other large herbivores, is associated with rain.

ANNE SOLOMON

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Rocky Bestiary

DIVERSE ANIMALS occur in San art. The aardvark (*a*), overlaid with human figures, is from the Giant's Castle Game Reserve in South Africa. The giraffes (*b*) are from the Erongo Mountains in Namibia. Some rain animals resemble a hippopotamus (*c*); this one is from Zimbabwe. The delicate rhebok (*d*) is a game animal. The painting actually contains two rheboks, superposed. (The second rhebok has its head downward.) Humans and large herbivores are believed to possess *n/ow,* a quality linked to birth, death and weather: good *n/ow* brings rain, whereas bad *n/ow* is associated with harsh conditions. The San's preference for portraying humans and large herbivores may have to do with their possessing *n/ow*.

a

b

c

d

ANNE SOLOMON (*hippopotamus* and *rhebok*); ROGER DE LA HARPE (*aardvark*); NHPA (*giraffe*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Mysterious Engravings

ENGRAVINGS are found in arid areas, and the choice of subjects is puzzling. The boulder (*right*), from northern Cape Province in South Africa, depicts antelopes. (Near its top left are sticklike figures of a European couple, probably added later.) Assorted animals are also chiseled into this cliffside in Khorixas, Namibia (*below left*). But many engravings, such as these in the desert of southern Namibia (*below right*), show abstract figures. Such patterns are now believed to have been inspired by hallucinatory experiences.

ANNE SOLOMON (*top*); ROGER DE LA HARPE (*left*); NHPA (*right*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Many sites contain a profusion of diverse imagery, different in theme and style. Some may have been used over centuries for a variety of purposes, others only once or twice, for a particular end. Recent interpretations have emphasized healing of the sick, an action only rarely rendered explicitly in rock art. However, some images previously thought to depict rain animals may be of the Rain Bull himself. Because he is the death figure, these images may have been painted in an effort to cure physical illnesses.

Of course, paintings and engravings depicting European colonists, wagons, soldiers and domestic animals may well be records of real events rather than ritual occasions. In addition, some rock art appears to reflect interactions between the San and other groups. John E. Parkington and his collegues at the University of Cape Town have suggested that handprints found along the southwestern coast, usually overlying earlier art, may have been the work of Khoi herders. Depictions of cattle introduced by the migrating herders and farmers, as well as iron artifacts, maize cobs and glass beads found in excavations, all testify to San involvement in other African economies.

New Interpretations

THE FINAL IMAGES themselves may not be alone in creating significance to the prehistoric artists. The act of painting itself may also have been important. Recent research in anthropology and art history has drawn attention to the process of art making and of the materials used, as opposed to creating an end product for viewing (as is usual in Western arts). This may be especially relevant to understanding San arts.

Probably each step of the painting process in San art carried cultural significance. One indigenous account from 1910 mentions ritual preparations that involved pigments being ground by women at full moon. In my research, I have emphasized the symbolic and spiritual significance of technically nonessential substances, such as fat and eland blood, that were said to be added to the paint mixture, presumably as magical aids. The act of making art, it appears, exerted magical effects that could influence the spirits and help control fate.

ENCOUNTER with Europeans, and their guns and horses, is depicted in Beersheba Shelter in the Drakensberg Mountains. Conflicts claimed the lives of both San and colonists. The San once occupied most areas of southern Africa. Today San speakers live principally in parts of Botswana and Namibia.

Powerful analytical techniques are now available for identifying these paint ingredients and culture-specific "recipes" of ancient paintings. This information would not only help us understand the significance of rock art but is also of interest for reasons ranging from resource exploitation to ancient trade to contemporary conservation.

I have researched the use of pigments and paints, with a view to identifying "magical" additives. This work, with the assistance of soil scientists at the University of KwaZulu-Natal, has involved a suite of techniques, including x-ray fluorescence (to provide quantitative data on minor and trace element composition), x-ray diffraction (to reveal crystal structure and parent rock types of paint ingredients), and environmental scanning electron microscopy (to yield qualitative data on elements present). Another promising technique that we have used experimentally is synchrotron radiation analysis. This technique, suitable for tiny samples, allows for x-ray fluorescence and x-ray diffraction of the same spot. So far these sophisticated research tools have generated more questions and problems than answers. The variability in both pigments and paints may be too vast to produce results relevant to answering archaeological questions.

The function and many meanings of rock art in history and prehistory still generate debate, although a broadly spiritual role is now well established. As an extraordinary and evocative record of the past, San rock art is becoming part of the culture of postapartheid South Africa. Yet paintings face many threats. Through the combined efforts of a spectrum of specialists, we hope to ensure that the rock art will endure as a testament to an ancient African culture, tragically displaced. SA

ARON D. MAZEL *University of Newcastle*

MORE TO EXPLORE

People of the Eland. Patricia Vinnicombe. University of Natal Press, 1976.

Images of Power: Understanding Bushman Rock Art. J. David Lewis-Williams and Thomas A. Dowson. Southern Book Publishers, 1989.

Hunters and Herders of Southern Africa. Alan Barnard. Cambridge University Press, 1992.

The Rain and Its Creatures: As the Bushmen Painted Them. Bert Woodhouse. William Waterman Publications, Johannesberg, 1992.

Miscast: Negotiating the Presence of the Bushmen. Edited by Pippa Skotnes. University of Cape Town Press, 1996.

Rock Paintings of South Africa: Revealing a Legacy. Stephen Townley Bassett. David Philip, Cape Town, 2001.

The Broken String: The Last Words of an Extinct People. Neil Bennun. Viking (Penguin U.K.), 2004.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Syria

Life and Death in NABADA

By Joachim Bretschneider

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Excavations in northern Syria reveal the metropolis of Nabada, founded 4,800 years ago. Its elaborate administration and culture rivaled those of the fabled cities of southern Mesopotamia

Since the end of the 19th century, archaeologists have strived to uncover the ancient history of the Near East and to trace the region's biblical roots. They focused on the Fertile Crescent between the rivers Euphrates and Tigris in Iraq, where lie the ruins of the ancient city-states of Assur, Babylon, Ur and Uruk. The architecture, tablets and other artifacts of these cities illustrate a tumultuous history that began more than 5,000 years ago. Scholars assumed that only here, in southern Mesopotamia, were the earliest centers of power and the origins of civilization. The people of Mesopotamia—such as Sumerians, Babylonians and Assyrians—invented writing, the wheel and beer; created the first law books; established mathematics and astronomy; and improved ceramic, metal and stone manufacture. Even biblical motifs such as the garden of paradise, the great flood and the Tower of Babel have Mesopotamian roots. When the Babylonian king Nebuchadnezzar II (605–562 B.C.E.) sent the Judeans into Babylonian exile and destroyed the walls of Jericho, he substantially affected the history of Palestine.

Until quite recently, the steppes of northern Mesopotamia (in present-day Syria) were largely neglected. But when the war between Iraq and Iran closed access to southerly sites in the 1980s, archaeologists were forced to pay more attention to peripheral areas. A research team led by Marc Lebeau of the European Center for Upper Mesopotamian Studies and Antoine Suleiman of the Directorate-General of Antiquities and Museums (Syria) began to excavate Tell Beydar, a large mound—or "tell"—rising out of the flat steppes near the Khābūr River. The team also consisted of the universities of Leuven (Karel Van Lerberghe), Venice (Philippe Talon), Brussels (Lucio Milano) and Münster (Bretschneider). In these steppes, a tell indicates a long-buried city; after 10 years of intensive research, we can now say that Beydar did not disappoint.

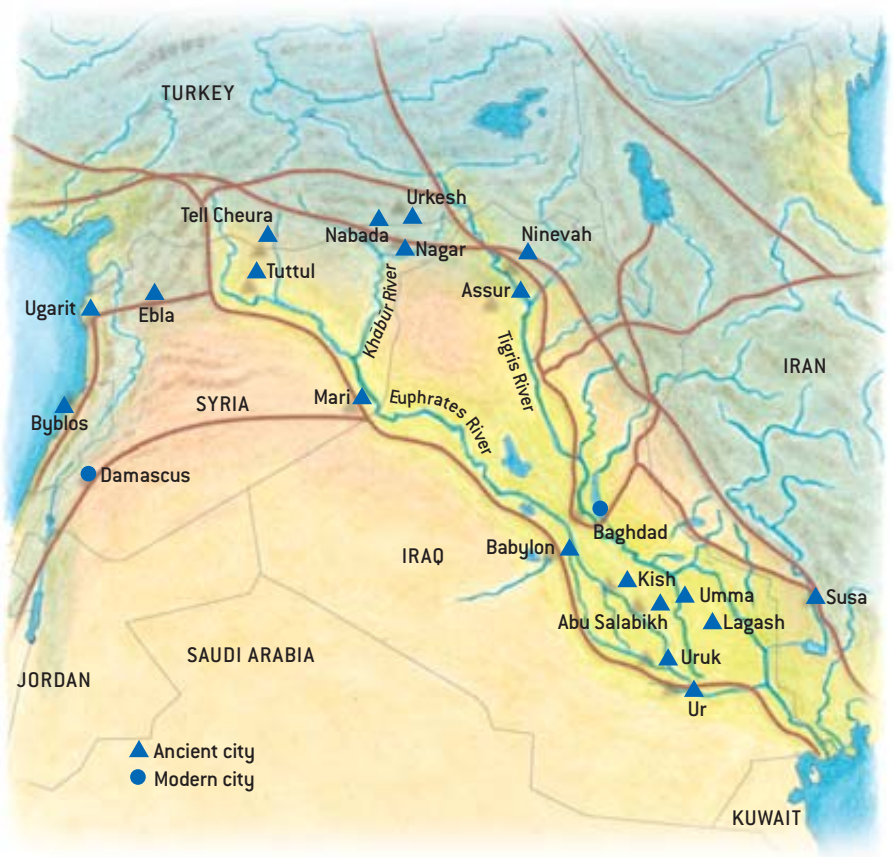
Inside the 28-meter-high circular hill archaeologists found a complex almost as old and large as the citadel of

PALACE RUINS of the ancient city of Nabada under the mount of Tell Beydar (*left*). Arched doorway in the 4,500-year-old palace (*right*).

PHOTOGRAPHS BY JOACHIM BRETSCHNEIDER

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

The Cities of Northern Mesopotamia



STEPPES OF NORTHERN MESOPOTAMIA near the Khābūr River in present-day Syria are home to the ruins of numerous ancient cities, including Nabada. Nabada reached its peak of prosperity in the third millennium B.C.E., when political and economic power in the region were being concentrated in a few large centers: Kish, Lagash, Umma, Ur and Uruk in modern Iraq; and Chuera, Ebla, Mari, Nagar, Nabada and Tuttul in northern Syria. Nabada and nearby cities probably served as relay stations for caravans traveling the ancient routes (*red lines*) between Anatolia (present-day Turkey) and Babylonia or between Egypt and Mesopotamia. Archaeologists have uncovered a variety of artifacts at Nabada that reflect the city's role as a cultural and trade center (*photographs at right*). —*J.B.*

ancient Troy. The city, known in ancient times as Nabada, evidently enjoyed its greatest prosperity during the early Bronze Age, between 2800 and 2200 B.C.E., and the excavation concentrated on this period. Our aim was to understand the birth of city-states—the metropolises that ruled the surrounding countryside and, sometimes, other cities—in northern Mesopotamia. Complex administration, as evinced by written tablets and seals, evolved at this time.

Early in the 20th century German archaeologist Max Freiherr von Oppenheim demonstrated that the vast and now abandoned spaces of northern Syria were densely inhabited in ancient times. He also surveyed some of the more conspicuous circular tells, which cluster around the upper course of the Khābūr River. Such a tell, which he described as "Kranzhügel," or "wreath hill," is surrounded by a ring, the decomposed mud brick of a circular fortification wall. Von Oppenheim suggested that the lower levels of these towns were all created at around the same time and formed a single political or cultural unit, the so-called Kranzhügel culture.

Excavations at Tell Chuera revealed an urban complex dating to the first half of the third millennium B.C.E. Although Chuera is made of sun-dried mud brick, as was common in the metropolises of southern Mesopotamia, its temples were constructed on monumental stone terraces along a procession road.

Who built Tell Chuera or where these people came from remains a mystery. Curiously, Tell Beydar, the only other circular tell to be systematically investigated, is turning out to be quite different.

In Tell Beydar we discerned three main phases of occupation. Researchers date these phases by a combination of techniques: comparing trends in pottery design; measuring the occurrence of radioactive carbon in ashes and other debris of organic origin; and relating names occurring on tablets with those known from other sources. In my view, the dates are uncertain by only about 50 to 100 years, although other scholars differ.

Wreath City

THE FIRST AND MOST significant phase began with the founding of Nabada around 2800 B.C.E. Apparently following a set plan, the builders constructed a circular settlement with a diameter of 600 meters. They protected it by a wall five meters thick, built on a raised embankment. Four gates, now seen as gaps in the buried outer ring, penetrated this wall. Peasants' dwellings and artisans' quarters clung to its

THE AUTHOR

JOACHIM BRETSCHNEIDER studied archaeology and Oriental studies at the Westfälische Wilhelms University in Münster, Germany. He is an associate professor at the Catholic Universities of Leuven and of Louvain la Neuve in Belgium. Bretschneider led the German team from University of Münster, which worked between 1992 and 2000 at the Euro-Syrian excavations at Tell Beydar, and is now excavating with a Syro-Belgian team in Tell Tweini (ancient Gibala) on the Syrian coast.

PATRICIA J. WYNNE AND BRYAN CHRISTIE

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Ivory furniture inlay, 1400 B.C.E.

Ceremonial vase, 1400 B.C.E.

inner side as in Europe's medieval cities. About 20 tombs have so far been excavated near the wall, whose elevated base apparently served as a cemetery.

The tombs, some of which also lie beneath the houses, provide a clue to the people's religious beliefs. In one case, a shaft led to the burial chamber, constructed of mud brick and sealed. The dead man, apparently an important official, lay in a fetal position surrounded by weapons, jewelry and pottery to ease his passage to the afterlife. Another grave was supplied with a bronze ax, ceramic jars filled with wheat and many other objects. Whereas soldiers were buried with their weapons, artisans were interred with their work tools; social stratification is evident in the varying richness of the burial gifts.

Some later Babylonian sources describe a tomb as an entrance to the underworld, a place of damnation from which there is no return. Death in the Ancient Near East was a reliable companion and an accepted part of life. Nobody believed that death could be escaped, because from birth onward the gods provided people with death. A life expectancy of 35 years for women, 45 for men, and an enormously high childhood mortality did not leave any doubt. Offerings of food and drink by the relatives appeased the spirits of the dead in this dark and gloomy realm. Evidently the citizens of Nabada adhered to a similar belief.

An inner wall 300 meters in diameter protected the heart of the settlement. It is very likely that traders were allowed to spend the night between the two walls, safe from highway robbers but not themselves posing a danger to the sleeping citizens of Nabada. The double wall may also have let peasants from surrounding regions take refuge in the city in times of trouble. From the gates, radiating streets led to the central mound, on which rose a palace. Lining the city's streets were blocks of houses, filling the space between the palace and the inner city wall. Drainage systems evacuated water from houses and courtyards into channels underlying the paved streets and alleys.

In the eastern section of the city stood a remarkable 27-meter-long building whose walls still rise up to three meters. Wide, arched doorways connected the structure's four rooms, a sign of advanced architecture. Low sockets in the walls show that the rooms were fitted with elevated wooden floors for storing grain or wool; the supplies stayed dry thanks to the ventilation underneath them. Storehouses of such size suggest a complex economy.

For its size, the city inside Tell Beydar had surprisingly few houses: most of it consisted of a palace, rising like a fortress on the central, 20-meter-high acropolis. (That is, at least 20 meters of cultural levels and the ruins of several palaces, all from the early Bronze Age, underlie the present excavation.) The royal complex covered about 50 by 60 meters, comprising almost 50 rooms on the ground floor alone. Many of the mud-brick walls are well preserved, being up to four meters high and having intact doorways frequently spanned by a vault. A number of rooms boast a fine, white lime plaster on their walls.

A large central courtyard provided easy access to the palace's many rooms. Friezes with clay rosettes decorated the walls of the main rooms, and stairways led up to a throne room (where the king met his subjects) and ceremonial chambers at a higher level. These rooms, which archaeologists recognize by their altars and other characteristic features, had annexes supplied with terra-cotta shafts up to 20 meters deep. The small rooms may well have been used for ritual washing and purification, with the shafts providing drainage.

From this large courtyard a smaller one toward the southeast could be reached. From here other staircases led to a higher level, where the living quarters of the ruler may have been situated. All around the perimeter of the palace are

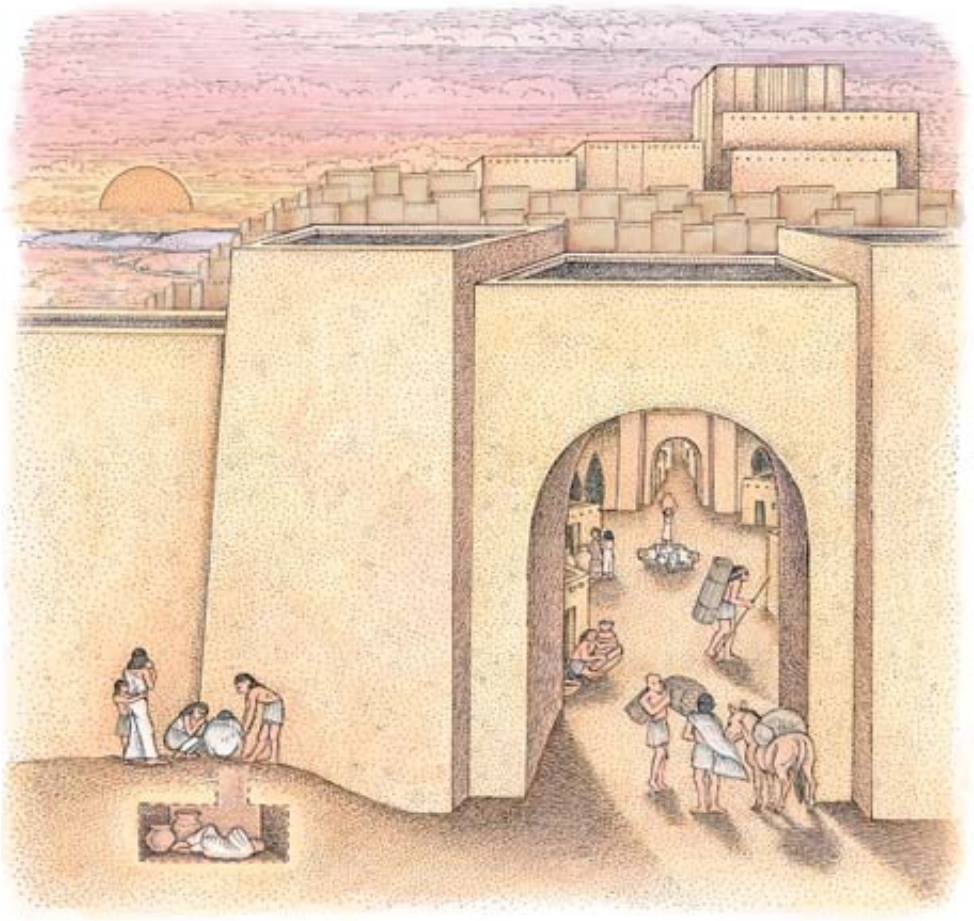
JOACHIM BRETSCHNEIDER

SANDSTORMS, HEAT AND DUST are among the difficulties facing archaeologists who work on the site of the palace ruins.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Life inside Nabada's Walls

NABADA WAS FOUNDED around 2800 B.C.E., with the construction of a circular settlement 600 meters in diameter. The early inhabitants protected their town with a wall five meters thick built on a raised embankment (*right*). Even before the mound, or tell, was excavated, the remains of the city's outer walls and the central mound were evident in the Syrian desert (*photograph at center*). About 20 tombs have been excavated from this embankment; in one tomb, a shaft led to the burial chamber, which was made of mud brick and then sealed. The dead man, apparently an important official, lay in a fetal position surrounded by gifts such as weapons, jewelry and pottery, which were thought to ease his passage to the afterlife (*photograph at far right*). An inner wall 300 meters in diameter protected the heart of this settlement: rising from a central 20-meter-high mound stood Nabada's palace (*inset*). The royal complex covered about 50 by 60 meters, comprising almost 50 rooms on the ground floor alone. A large central courtyard provided easy access to the palace's many rooms. —*J.B.*



storage rooms, still filled with huge ceramic jars that once brimmed with goods. The southern part of the palace featured elaborate wall niches and altar platforms. The ruler was interred here beneath the floor, following an old Syrian practice (we found the undisturbed grave in the year 2000). In a three-chamber tomb more than three meters under the floor a tall man of more then 1.8 meters was buried with all his weapons and a huge amount of ceramic vessels that contained food offerings. A circle of stones with a dagger inside, another stone circle covering animal bones and an anthropomorphic statue in clay are early records of an unknown burial ritual.

In 1999 excavators uncovered an intriguing set of terraces. These suggest that we are likely to find giant stairways leading up to the palace from the southern gate of the outer wall. They would have formed a steep ramp or stepped pyramid, lined with temples, the whole probably creating a monumental entrance for visiting dignitaries and the elaborate processions accompanying them.

Accounts of Nabada

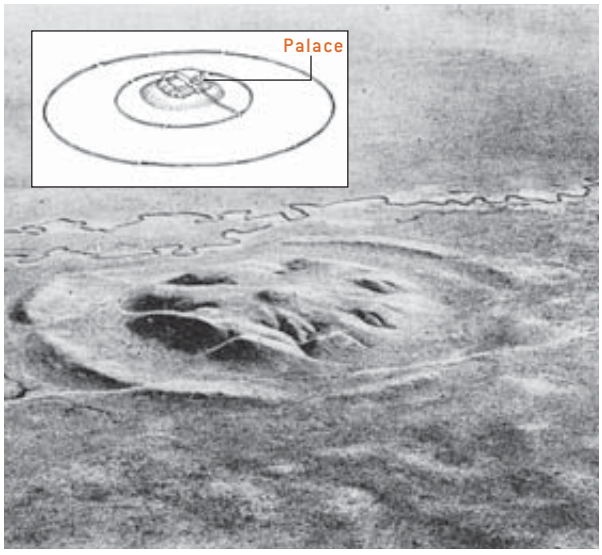
IN 1993 AND 1994 excavators made a surprising discovery: a collection of clay tablets with a meticulous record of the palace's daily accounts. Since then, we have found 216 tablets inscribed with a cuneiform script familiar from southern Mesopotamia. Most of the tablets were part of the floor of a house; they had evidently been discarded and reused as building material. We came across a heap of trash thrown over the palace wall, including many tablets. These written documents date to 2350 B.C.E., their age making them an important key to the culture.

The tablets are curious in one aspect: the script is Sumerian, but the language is Semitic. Philologists assume that Semites migrated into Mesopotamia around the end of the fourth millennium B.C.E., intermingling with Sumerians and finally dominating Mesopotamian civilization. They adopted the Sumerian script—the only one available—to express their own language. The tablets of Tell Beydar represent the largest collection of Old Semitic texts found in the Khābūr area.

The Semitic royal cities of Mari and Ebla had yielded archives of this period. Mari, discovered in the 1930s, lay halfway between southern and northern Mesopotamia and formed a link between the two cultures. Around 2400 B.C.E. it ruled much of the region to its north. Ebla, in western Syria, was discovered in 1968 by an Italian team led by Paolo Matthiae of the University of Rome "La Sapienza." Here the archaeologists found an extensive archive of cuneiform tablets, which describe trade relations with Nagar and Mari. Nagar was said to lie on an international trade route between the mountains, which were rich in ores, and southern Mesopotamia, with its major center at Kish.

PATRICIA J. WYNNE

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.



TELL BEYDAR in 1927, before excavations began.

BURIAL CHAMBER near city wall.

Some of the tablets, deciphered by Walther Sallaberger of the University of Munich, speak of neighboring hamlets administered by Nabada. One group of texts informs us of the care taken of travelers, recording precisely the rations for people and animals. At one time, 11 teams of 44 onagers—a subspecies of the wild ass now found mainly in the north of Iran—had to be taken care of for four days, costing the city a considerable amount of grain.

Another text mentions the king of Nagar, who apparently ruled Nabada around 2350 B.C.E. This king visited the "province"—that is, Nabada—on occasions such as council meetings and ritual celebrations. An unearthed tablet lists delicacies provided to a woman named Paba, possibly the queen of Mari and spouse of King Iblul-il. Her visit illustrates the city's far-reaching political connections.

Daily activity in this ancient city is also revealed in the impressions made by seals. High officials in the palace possessed finely carved stone cylinders that they rolled over gobs of clay to seal doors, containers and documents [*see illustration on next page*]. We found many such seal impressions in Tell Beydar, on pots and doors of storage rooms and also at the entrances of the throne room and the temple. These rooms may have been opened only on special occasions. According to Greta Jans of the University of Leuven, a member of our group responsible for seals (glyptic material), many of the sealings are miniature masterpieces depicting celebrations, lively traffic on trade routes, war and diplomatic activity.

Historians now know that during the first half of the third millennium B.C.E., political and economic power in Mesopotamia were being concentrated in a few large centers. Thus, cities such as Kish, Lagash, Umma, Ur and Uruk in present-day Iraq and Chuera, Ebla, Mari, Nagar, Urkesh, Nabada and Tuttul in northern Syria came into being. (The earliest levels of Troy in northwestern Asia Minor and the early occupation of Byblos on the Lebanese coast also belong to this era.) Each of these cities contained fortification walls, palaces, storage areas and temple complexes.

The economic and political structure of southern Mesopotamia is rela-

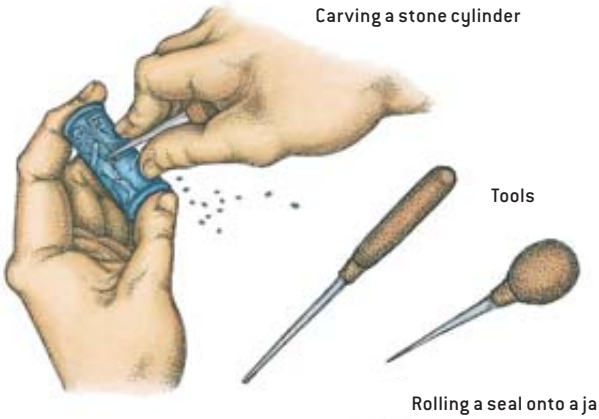
STUNNING VIEW from the acropolis mount of Nabada across the landscape of north Mesopotamia.

POI DEBARD (*photograph*) AND PATRICIA J. WYNNE (*inset*) (*top left*); JOACHIM BRETSCHNEIDER (*top right* and *bottom*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Writings from Nabada

Seal found on a container at Nabada



Rolling a seal onto a jar

A PICTURE OF WHAT LIFE was like in Nabada can be found in the impressions made by seals. To produce a seal, palace officials rolled a finely carved stone cylinder over wet clay; when the clay dried, it sealed shut pots, documents, even doors. Many of the seals depict celebrations, lively traffic on trade routes, war or diplomatic activity. The photograph above shows a seal illustrating the use of wagons in both religious ceremonies and in war. —*J.B.*

tively well understood. Burgeoning agricultural production allowed livestock to be raised communally. The surplus of food enabled specialized artisanal and administrative skills to flower, and a flourishing trade in raw materials such as copper spurred the evolution of centralized authority and power—as well as warfare. Perhaps the most far-reaching innovation was the craft of writing.

It is not clear that the northern cities followed a similar pattern. As in the south, the larger cities probably controlled extensive regions with vital trade routes. Nabada and its neighboring cities seem to have functioned as relay stations for caravans traveling the ancient routes between Anatolia (present-day Turkey) and Babylonia or between Egypt and Mesopotamia. Important families and a council of elders ruled, as in the south, and offered sacrifices to local and regional deities. A growing number of settlements also led to armed disputes over water rights, agricultural and pasture land, and control of trade routes.

Many questions remain. Historians would like to know who founded Nabada and other northern cities, where they came from, what language they spoke, and around what political and moral principles their society was organized. Moreover, Nabada appears to be quite distinct from the other circular tell that was examined, Tell Chuera. (Tell Chuera is, however, older than the levels so far excavated at Tell Beydar, and so a direct comparison cannot be made.) Chuera had monumental stone architecture (not just mud brick as in Nabada), and, more significantly, 15 years of digging have as yet yielded no evidence of writing at the Chuera site. Nabada was probably more allied with southern Mesopotamia than with Tell Chuera, which had closer links with the civilization in Turkey.

After 500 years of prosperity, Nabada was abandoned around 2350 B.C.E. Why, we do not know; the other known cities of northern Mesopotamia declined at the same time. Perhaps the kings of Akkad, who conquered many of the city-states of Mesopotamia, burned Nabada as they did Ebla. At Nabada, however, only a few indications of fire or other destruction have been found.

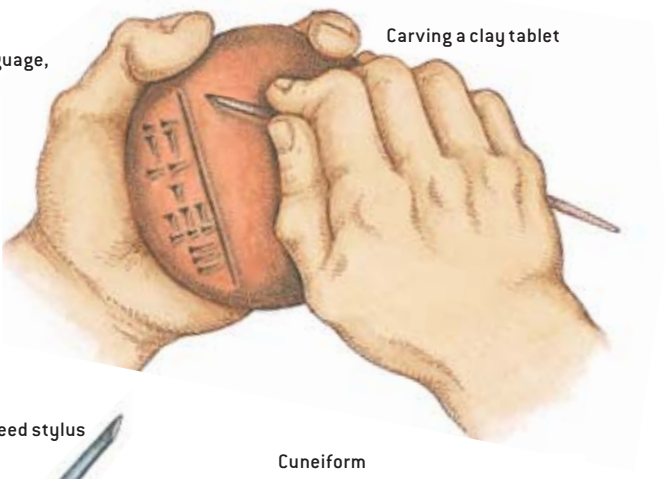
Some architectural changes may provide a clue to this mystery. Shortly before deserting the palace at Nabada, its inhabitants added a sanctuary and renovated several of the ritual rooms. Could this religiously motivated activity have been prompted by some natural event, such as a drought? Or do the deep fissures and cracks in the palace walls suggest a phase of intense earthquakes? Hartmut Kühne of the Free University of Berlin has suggested that a large increase in population caused the natural resources of the region to be overexploited, forcing a migration. It may simply be that a reduction in the number of caravans traveling the trade routes

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

A New Language

WRITINGS FOUND at Nabada are unusual: the script is Sumerian, but the language is Semitic. The tablets of Tell Beydar (*an example is shown at the right*) represent the largest collection of Old Semitic texts found in the Khābūr area. Language experts have translated the symbols; a sample dictionary is shown at the bottom right. —*J.B.*

Tablet written in a Semitic language, with Sumerian script



Carving a clay tablet

Reed stylus

made the northern cities uneconomical.

Tell Beydar was briefly reoccupied a few hundred years later. Around 2250 B.C.E., however, it suffered from plundering, decline and erosion. In the next millennium the Hurrians, a people who originated in the mountains of East Anatolia, arrived in the region, founding new royal cities such as Urkesh (excavated by Giorgio and Marilyn Buccellati at Tell Mozan). Around 1600 B.C.E. a Hurrian empire called the kingdom of Mitanni developed in the Khābūr area. At its apex, around 1400 B.C.E., it extended all the way from the Mediterranean coast to the Zagros Mountains. The Hurrians settled amid the ruins of Nabada, 1,000 years after the fall of the early Bronze Age metropolis.

In the lower town surrounding the abandoned palace of Nabada, outside and to the west of the fortification wall, some preliminary excavations have located remains of the Mitanni period. We came across a ceremonial vase decorated with rams' heads and a collection of ivory reliefs depicting lions and bulls that were probably once used as inlays for furniture. The Hurrians did not, however, build a palace, and overall Tell Beydar was far less important at this time than in its heyday as Nabada.

The empire of Mitanni perished in its turn, and in the eighth century B.C.E. Assyrians conquered the Khābūr region. From Assur, their capital city to the northwest of Babylon, these warlike people increased in influence after 1100 B.C.E. For a brief period, they even advanced as far as Egypt. The Assyrians were feared by their enemies: they are said to have deported entire populations and slaughtered opponents without respect to sex or age.

The Assyrian invaders settled on top of the earlier Hurrian occupation in the lower regions of Tell Beydar. Their stay was brief; Babylonians and Medes (from what was then Persia) combined their forces and attacked them. "All who hear the news of you clap their hands at your downfall," wrote the prophet Nahum in the Old Testament when Nineveh, the last and greatest capital of the Assyrian Empire, was reduced to ashes in 612 B.C.E.

With the fall of the Assyrian empire, Tell Beydar once again returned to dust and silence. SA

MORE TO EXPLORE

History of the Ancient Near East ca. 3000–323 B.C. Marc Van De Mieroop. Blackwell, 2003.

Tell Beydar, the 1995–1999 Seasons of Excavations. Edited by M. Lebeau and A. Suleiman. Brepols, 2003.

La Mort en Mésopotamie. A. Berlejung and J. Bretschneider in *Pour la Science,* No. 315, pages 48–54; January 2004.

Third Millennium Cuneiform Texts from Tell Beydar (Seasons 1996–2002). L. Milano, W. Sallaberger, P. Talon and K. Van Lerberghe in *Subartu XII.* Brepols, 2004.

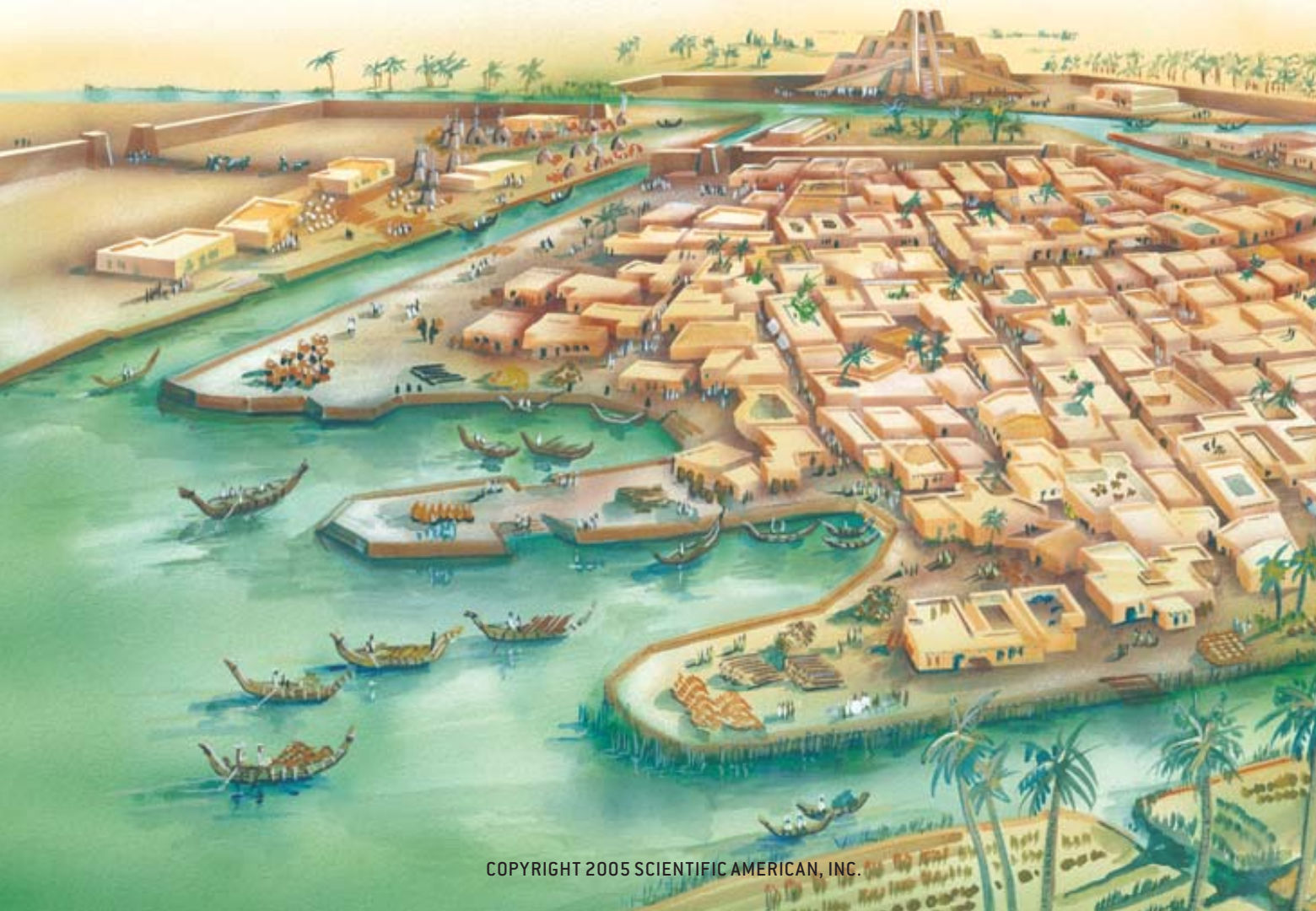
PHOTOGRAPHS BY JOACHIM BRETSCHNEIDER; ILLUSTRATIONS BY PATRICIA J. WYNNE

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Iraq

The Tapestry of Power in a Mesopotamian City

By Elizabeth C. Stone and Paul Zimansky



COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Mashkan-shapir was for a brief time one of the most important cities in the world. Its remains challenge traditional notions of power distribution in early urban society

MASHKAN-SHAPIR at the height of its power in about 2000 B.C.E. was the second capital of the Mesopotamian kingdom centered at Larsa. Politics, trade, manufacturing and religious ceremonies all took place within its walls in a society that, the authors argue, appears to have been based more on consultation than on coercion.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

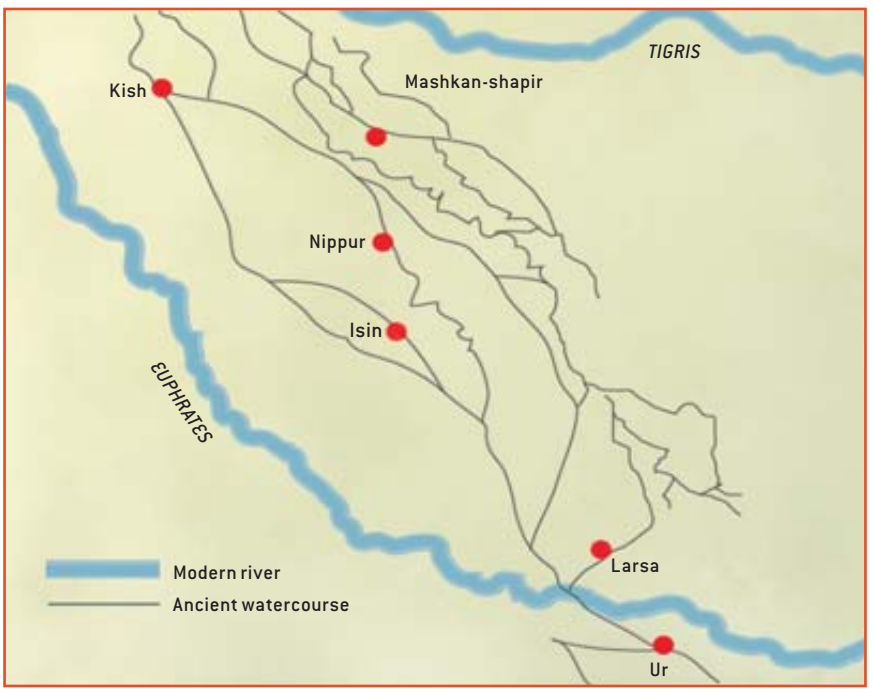
Remains of the world's first cities are the most noteworthy features of the landscape in southern Iraq, and for nearly two centuries archaeologists have probed them and puzzled over their artifacts. Built up over the course of five and a half millennia of intermittent occupation, these tells—mounds of building rubble and associated artifacts—can be as large as a mile in diameter; some rise more than 100 feet above the plain. Babylon, Ur, Uruk, Nippur and Kish have yielded abundant evidence of the material culture of Mesopotamian society. Thanks to their citizens' relatively imperishable writing medium—clay tablets—they have also provided detailed textual testimony on political, intellectual, religious and social institutions.

Nevertheless, the physical and social organization of these most ancient cities is still poorly understood, for a variety of reasons. Paradoxically, the very richness of evidence has led to ignorance. The tells are so massive that even the best-financed field parties can excavate only tiny fractions of each city. More important, the arrangements of buildings that archaeologists uncover generally do not represent a city that actually existed at one particular time. The ancient inhabitants built on earlier structures in some cases and swept them away or modified them in others. One might imagine a similar problem facing archaeologists trying to understand London a few thousand years hence: they would be confronted by the mixed remains of modern skyscrapers, Victorian buildings, Norman castles and even a Roman garrison; reconstructing the city as it looked during any given period would be almost impossible.

Urban sociologists have long known that the plans of contemporary cities reflect patterns of social organization. Our own survey of non-Mesopotamian early cities shows that similar conclusions can be drawn about early urban sites. Where power is highly focused and based on coercion, centers of administration, religion, manufacture and trade cluster together, surrounded by residences of the elite. In contrast, societies in which diverse groups share control and in which decision making takes place at various levels of the social hierarchy show little or no evidence of such concentration. The intimate ties between elites and the rest of the population in these decentralized cities are mirrored by a mixture of rich and poor houses in each of the residential districts.

Where are humankind's first cities to be placed in this spectrum? Archaeologists have tended to emphasize centralization, but a close look at their reasoning, combined with our recent findings at a site called Mashkan-shapir, indicate that this view needs revision. Early excavations in Mesopotamia focused on seats of wealth and power—palaces and temples—and led researchers to take a similarly narrow view in reconstructing the society that built them. Yet concentration on the physical remains of high status obscured the fact that Mesopotamian texts do not identify clearly differentiated social classes. Instead they record the importance of general assemblies in decision making.

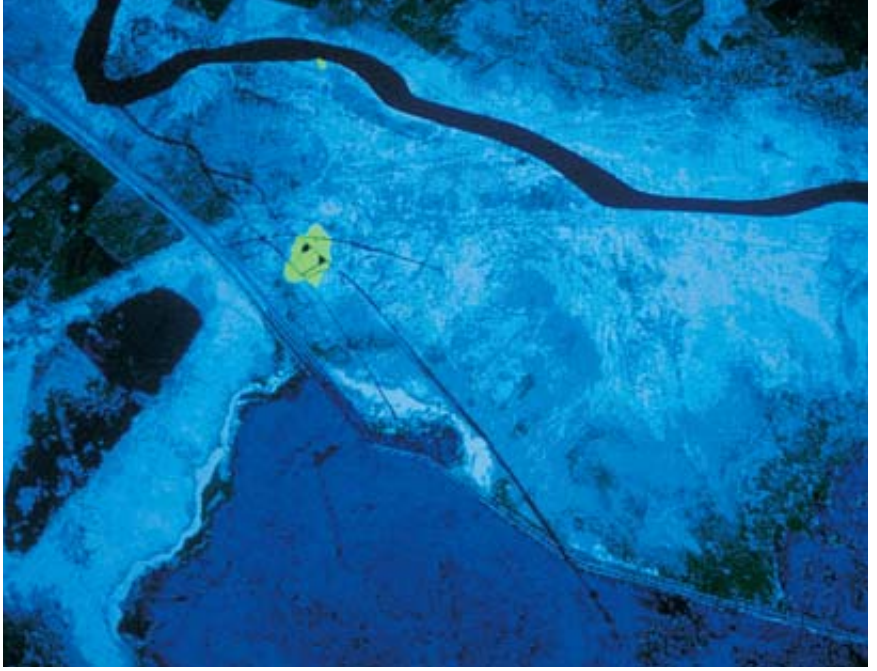
There may also be a more subtle bias at work. Historians recognize that industrialism and capitalism have so transformed the world that there are no modern analogues for ancient cities. Rather than considering a wide range of potential urban organizations, however, some scholars have perhaps too readily posited a unified model for a "preindustrial city" based on a few, well-studied (and centralized) exam-



ANCIENT MESOPOTAMIA covered the region between the Tigris and Euphrates rivers in what is now Iraq (*map, above*). Mashkan-shapir (*right*) rose to prominence because of its strategic position near the Tigris; it controlled trade in many goods that came down the waterway from the north. A satellite photograph (*opposite page, top*) shows the location of the city (*green*), its canals and the Tigris at the time Mashkan-shapir flourished.

preceding pages: JANA BRENNING; *this page:* LUCY READING-IKKANDA

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.



ples. In devising this model they have rarely looked further afield than ancient Greece and sometimes no further than medieval Europe.

As a result, researchers have in effect taken for granted that cities in Mesopotamia were shaped by the same forces as were later European ones, among them a stable agricultural base and a fixed value for any given plot of land. In fact, the economic base in this region was anything but geographically stable—as indicated by the importance of nomadic herding. Even cultivated land was impermanent: annual floods, high evaporation rates and rapid poisonous salinization of land under cultivation led to a constantly shifting mosaic of rich irrigated fields and orchards, deserts and marshes, in which wealth or power had little to do with permanent control of a particular parcel. Detailed descriptions of many preindustrial urban civilizations—in West Africa, the Islamic Middle East and the New World at the time of the conquistadors—show considerable variability in organization; they also suggest a link between the permanence of agricultural land and the degree of social and political centralization. There is thus no reason to assume a priori that Mesopotamian cities were especially centralized.

An Untouched Site

THE ARCHAEOLOGICAL project that led to the discovery of Mashkan-shapir came about when we decided to attack the question of urban organization by seeking out a site that had been occupied only during a single period. The ruins of such a short-lived city would provide a snapshot of urban layout; by analyzing that physical organization, we would be able to draw some conclusions about whether it arose through coercion by priests and kings or by consensus among diverse segments of society. We were looking for a site that was of urban scale but otherwise quite different from the great cities that had been investigated before—a site occupied for a short time and left relatively undisturbed since its abandonment.

Looking through data collected by other archaeologists on the overall distribution of ancient settlements in Iraq, we chose a site that Robert McC. Adams, then at the University of Chicago, had found in the mid-1970s. He had given it a number but no name.

Our initial visit in January 1987 took place under less than ideal circumstances—it coincided with the first day of Iran's "final offensive" against Iraq during the Iran-Iraq war. Nevertheless, we could see that the site was littered with traces of occupation. Walls, pottery, graves, even ancient canals were all clearly visible across an area more than half a mile in diameter. Most of the shards dated to the first quarter of the second millennium B.C.E. Both the quantity and quality of the remains made it clear that the only recent visitors to this place, bedouin and their camels, had left it largely undisturbed.

The site stayed nameless for another two years while we made arrangements to return. Then, in 1989, shortly after we began our survey, we chanced on a chunk of baked clay near the remains of a gate in the city wall. The piece bore a cuneiform text. In short order we brushed clean 150 similar fragments, which together turned out to carry multiple copies of an inscription commemorating the wall's construction. On the third piece we examined were three clearly legible signs of the four that are used to write "Mashkan-shapir": the name of what was once, albeit briefly, one of the most important cities in the world.

Mashkan-shapir first appears in the historical record as a small sheep-rearing village on the fringe of the Mesopotamian heartland in the latter part of the third millennium B.C.E. It probably would have remained obscure had it not been for the political intricacies of the early second millennium. Shortly before 2000 B.C.E., an empire centered at Ur, which had controlled the entire alluvial plain, collapsed. For the next two centuries, several cities vied for he-

Our initial visit in 1987 coincided with the first day of Iran's "final offensive" against Iraq.

THE AUTHORS

ELIZABETH C. STONE and *PAUL ZIMANSKY* have collaborated for more than 30 years on the study of ancient cities in the Middle East. Stone, who received her Ph.D. in 1979 from the University of Chicago, is professor of anthropology at Stony Brook University, New York. Zimansky, who received his Ph.D. in 1980 from the University of Chicago, is professor of archaeology at Boston University.

COURTESY OF ELIZABETH C. STONE

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Diverse City

URBAN AREA about a kilometer square was separated into five regions by canals. Remnants of religious and administrative activities were found at the periphery. Private houses and workshops for stone, copper and pottery were found throughout the rest of the city; coppersmiths plied their trade along the main street of the central district. This relatively even distribution implies a city in which different classes lived for the most part side by side.

gemony, foremost among them Isin and Larsa. Larsa was probably more powerful, but Isin was farther upstream on the Euphrates River and so could impede its rival's access to essential commodities, such as wood, metal and stone, coming down the river from the northwest. Larsa countered by moving to control the eastern part of the valley and to secure access to the Tigris River. As Larsa's northern outpost, Mashkan-shapir quickly grew to urban size, eventually serving as a second capital for the kingdom.

The city retained its role after Isin was defeated, because the rise of Babylon under Hammurabi's rule in the early 18th century B.C.E. created similar competition for control of access to goods. Soon enough, however, Hammurabi's conquests, which reunited most of southern Mesopotamia, made Mashkan-shapir's strategic position irrelevant. The city was abandoned around 1720 B.C.E., and the watercourses that had sustained it fell into disrepair. Mashkan-shapir disappeared into the desert.

There is ample historical testimony as to what kind of a place Mashkan-shapir was during its brief flowering. As a second capital to Larsa, it was a political city where much diplomatic activity was conducted. It was also a gateway to the trade route up the Tigris. Finally, it housed a primary sanc-

IAN WORPOLE

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

tuary to Nergal, god of death, among the most powerful deities in the Mesopotamian pantheon. Because administration, religion and trade were the major activities in other large Mesopotamian cities, the organization of Mashkan-shapir has strong implications for that of other sites.

Difficulties in the Field

OPPORTUNITIES for work at the site have been constrained both by the time required to raise funds for extended fieldwork and by the political vicissitudes of the region. We undertook the initial exploration in two three-week campaigns in 1987 and 1989. From January through May 1990 we were able to work continuously at the site thanks to the support of the National Science Foundation, the National Endowment for the Humanities, the National Geographic Society and the American Schools of Oriental Research. We conducted a thorough surface survey and aerial reconnaissance to map the main features of the site, supplemented by modest excavations to determine the relation between surface traces and subsurface remains. We also made use of satellite imagery to understand local geology.

Shortly after we finished the first phase of the project and returned to the U.S., Iraq's invasion of Kuwait brought an end to archaeological work by foreigners. We had hoped that someday we would be able to use the results of our survey to make excavations at locations that would be most informative about the operation of this ancient city. We have now learned, however, that Mashkan-shapir was one of the victims of the looting of Mesopotamian archaeological sites that began after the 1991 Gulf War and has accelerated since 2003. A photograph taken from a helicopter by John M. Russell of the Massachusetts College of Art in January 2004 shows the complete destruction of much of the central part of the site.

Mapping Mashkan-shapir was not easy. The city's remains hardly form a tell in the traditional sense. The site has been seriously eroded by wind, which has reduced the latest buildings to foundations and left heavier artifacts exposed on the surface. Only in a few places do the contours of the site rise more than two meters above the plain.

As a result, larger architectural patterns, such as the path of the city wall, were difficult to make out from ground level. Indeed, Mashkan-shapir's wall is visible only from the air for much of its circumference, and in some places it has vanished entirely. Aerial reconnaissance was essential to our work. We took advantage of the site's strong winds to loft a camera-bearing kite. The elevation of the kite changed with wind velocity, and so the area included in each image varied considerably. We did our best to make up for these irregularities by taking many pictures and having a great deal of redundancy in our coverage.

The 1,600 aerial photographs we took would have been of little use in mapping were it not for software designed to facilitate analysis of satellite images and to create maps for city planners and geographers. We had marked the corners of the squares in our survey grid, each measuring 50 meters on a side, with crosses that would be visible in the photographs, thus making it possible to orient the images and compensate for geometric distortions caused by the swinging of the camera. Digitized versions of the images were corrected, recomposed at a uniform scale and assembled in a mosaic detailed enough to identify the position of each individual brick on the site's surface.

We combined aerial reconnaissance with a pedestrian survey based on the same 50-meter grid. A member of our team walked over each grid square in a pattern designed to ensure that nothing was missed, marking key features and artifacts with surveyor's flags. We indicated scattered fragments of bricks, potsherds, copper or ceramic slag, kiln fragments and bitumen on our map in terms of concentrations rather than individual pieces because there were far too many to count. From sampling in limited areas we estimated that at least 30 million pieces of pottery larger than a fingernail lay on the surface.

During the course of the survey, we also mapped graves, platforms of baked brick and mud brick, edges of canals and traces of the city wall. And we located more than 1,200 individual artifacts: tools, weapons, jewelry, pieces of statuary, plaques, figurines, small models and whole pots. The variable distribution of artifacts bore testimony to the complexity of this short-lived city.

For a broader view of the geography around Mashkan-shapir, we turned to an image taken by a French SPOT remote-sensing satellite in May 1988. The image reveals an ancient bed of the Tigris near the site, which explains why the city was built more than 20 miles from the nearest modern watercourse. The picture also shows the outlines of a series of canals originating in the river and bisecting the city.

A City of Canals

FROM THESE FINDINGS we were able to discern a great deal about life in Mashkan-shapir. Like all Mesopotamian cities of its era, it was surrounded by a mud-brick wall interrupted by a number of gates. We identified three gates. Two were for road traffic; they were located near major canals presumably because then, as now, roads ran along the waterways that served as vital lines of communication. The pylons of the third gate are on either side of a canal; perhaps it served to regulate either the flow of water or of water traffic.

Surprisingly, the city wall was not always built close to the edge of dense settlement. An area between the settlement and the wall remained empty, except for six isolated buildings that seem to have been storehouses. Many Meso-

Mapping Mashkan-shapir was not easy. The site has been seriously eroded.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

potamian texts suggest that commodity exchange took place near city gates, and so this space may have served as some kind of market. Another apparently unoccupied area, near a canal, may have been a garden. We know that some Mesopotamian cities incorporated such gardens because a map of Nippur, scratched on a tablet dated a few centuries later, shows a large garden planted on one corner of the city.

The city proper was laid out in five districts, separated by canals. A quadrilateral region in the middle was surrounded by four larger areas to the north, south, east and west [*see box on page 64*]. The biggest districts, to the north and east, were themselves divided by canals. Broad harbors occupied two of the canal junctions; they must have been centers for commerce.

Many of the city's buildings were lined up along the waterways, making the canals an integral part of the urban fabric. Mashkan-shapir is not the only Mesopotamian city known to have been arranged in this manner, but the extent of canals elsewhere has been obscured by the great height of the deposits that have filled them in. Streets, which were also covered by debris at other sites, are just barely visible at Mashkan-shapir. Some follow the lines of canals; others cut across districts. On one such street, the baked-brick traces of a bridge (or perhaps two quays) can be seen where the street crosses a canal. Excavations at other Mesopotamian cities have shown that the main streets were supplemented by a network of alleys that gave access to individual houses.

The aerial photographs reveal additional demarcations. One wall surrounded a segment of the western district, and another wall cut across the southern part of the central one. Both are similar to an internal wall at Ur, which marked the sacred space surrounding the city's primary temples.

The waterways formed an integral part of the urban fabric.

How were the political, religious, economic and social functions of Mashkan-shapir laid out within the physical structure defined by streets, canals and internal walls? From the ruins, we can tell where various activities took place.

The primary temple at Mashkan-shapir—that of Nergal—would have been the visual focal point of the city. Raised up on a platform or ziggurat, it could be seen for miles, and, much like a medieval cathedral, it was a symbol of power. The remains of the baked-brick and mud-brick platforms that seem to have supported the most important sanctuaries lie in the southern region, which was cut off by a canal. The religious character of these platforms was made clear by the discovery of 70 fragments of life-size terra-cotta statues of humans, lions, dogs and horses. Statues of lions frequently adorned the entrances of even minor temples in Mashkan-shapir's time, but archaeologists have found the more complex human and animal statues only at major cities such as Isin.

Across the canal in the central district was another area with religious overtones, identifiable by another platform—the only one so far discovered outside the religious quarter. This region contains traces of numerous burials and a concentration of such grave goods as jewelry and weapons. The area is also cut off from the rest of the settlement by a wall. Most graves at other Mesopotamian sites (and many at Mashkan-shapir) appear in domestic areas, and so this cemetery suggests that one segment of the society—perhaps that associated with the religious or administrative center—had a separate burial ground, probably with an attached temple.

A third distinctive region within the city was the walled-off enclosure in the west, which we believe was an administrative center. It contained a series of very regularly built structures, quite unlike the more haphazard construction of private houses. Although the structures clearly do not constitute a palace such as the one at Mari, which dates to the same era, they may have

Signs of City Life

ARTIFACTS recovered at Mashkan-shapir are evidence of the diversity of life there. The cylinder seal (*a*), made of imported carnelian, may have been used to seal official documents. Fragments of model chariots (*b*) may have played a role in oath taking. The copper harpoon (*c*) was used to catch fish in canals and rivers; the terra-cotta lion plaque (*d*) served as decoration in a building.

COURTESY OF ELIZABETH C. STONE

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

performed some of the same administrative functions. Like palaces elsewhere, this enclave at Mashkan-shapir is at the periphery of the city. Furthermore, during the 1990 season we excavated numerous unbaked clay sealings from the buildings in this enclosure. These pieces of clay, bearing the impression of carved stone seals, were attached to ropes that closed doors or were embedded in the material that closed storage jars, much as a wax seal might be placed on a letter. They have no place in domestic contexts.

The enclosure contained an oddity as well—a concentration of model chariots decorated with representations of the major gods of the city, Nergal and Shamash, the sun god. It is difficult to say for certain what function these small, two-wheeled vehicles served. Their prevalence in an official space rules out the possibility that they were toys. One possible interpretation is that they served to represent these gods in such legal issues as oath taking.

No Focus of Power

NO OTHER AREAS of specialized architecture at Mashkan-shapir have been identified by our survey. Everywhere else the artifacts may be characterized as domestic—figurines, small tools and weapons, commonplace jewelry (such as shell rings), and the traces of houses and burials.

The major roads and canals probably divided this large urban space into discrete residential neighborhoods, but if so they were not segregated by wealth or status. Stone bowls and metal objects (made of imported material and representing significant investments of labor) were scattered quite evenly. Had they been more prevalent in one area than another, an argument could be made for elite residential districts. Cylinder seals—ancient badges of office and items of considerable value in themselves—were also evenly dispersed.

Similarly, we found that manufacturing took place throughout the city. There seems to have been some concentration of "smokestack" industries, including pottery making on the southeastern, leeward side of the city, but artisans appear to have undertaken their work in houses surrounded by other residences. But this was not the only manufacturing district. Coppersmiths—their workshops marked by concentrations of copper slag—plied their trade along the main street of the central district, for example, but we found most decorative stones and their associated grinders in the southeast. There were two centers of ceramic production (marked by ceramic slag and kiln fragments), one in the north and one in the east. Both were clustered around the smaller canals that ran through these areas. In short, the spatial arrangement of manufacturing yields the same mostly decentralized picture as the arrangement of houses and artifacts.

PRISTINE SITE in 1987 was characterized by a scatter of ceramics, baked bricks and artifacts produced by wind erosion that could be used to understand the organization of the ancient city of Mashkan-shapir (*top*). By 2004 digging by looters had destroyed much of the central part of the site (*bottom*).

PAUL ZIMANSKY (*top*); JOHN RUSSELL (*bottom*)

Uncentralized System

OUR SURVEY of Mashkan-shapir does not appear to support a highly centralized model for Mesopotamian cities—or for their social organization. It is true that we identified clear foci of religion and administration. But they were sequestered in the southern part of the site. Indeed, they were separated from each other and from the rest of the city by major canals. Moreover, these potential power centers were far from the regions where commerce took place—the harbors and the known city gates. The production of goods seems to have been in the hands of artisans who lived within broader residential neighborhoods that housed both commoners and members of the elite.

The overall organization of Mashkan-shapir suggests that textual sources have not misled us about the broad involvement of Mesopotamian city dwellers in shaping their local power relationships. This conclusion, in turn, may reflect on earlier social structures: if citizens lived in a relatively uncentralized system during the Old Babylonian period, when Mashkan-shapir was thriving, it appears highly unlikely that local authority was more firmly in the hands of a small elite in earlier periods. As a result, the grounds for seeking the origins of civilization in processes of conquest and coercion seem, at the very least, far from compelling. SA

MORE TO EXPLORE

Cultural Atlas of Mesopotamia and the Ancient Near East. Michael Roaf. Facts on File, 1990.

Early Mesopotamia: Society and Economy at the Dawn of History. J. Nicholas Postgate. Routledge, 1992.

The Tell Abu Duwari Project, 1988–1990. Elizabeth C. Stone and Paul Zimansky in *Journal of Field Archaeology,* Vol. 21, No. 4, pages 437–455; Winter 1994.

The Archaeology of Mesopotamia: Theories and Approaches. Roger Matthews. Routledge, 2003.

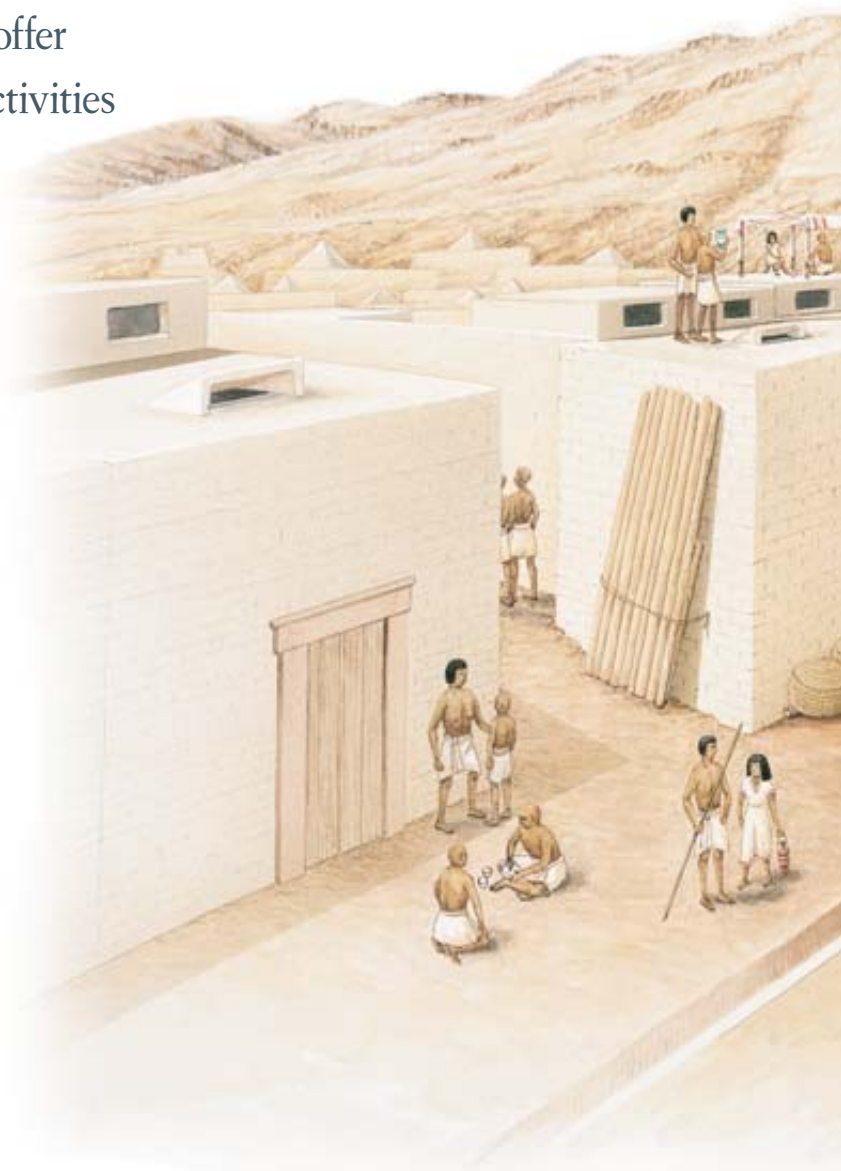
The Anatomy of a Mesopotamian City: Survey and Soundings at Mashkan-shapir. Elizabeth C. Stone and Paul Zimansky. Eisenbrauns, 2004.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Daily Life in Ancient Egypt

Workmen and their families lived some 3,000 years ago in the village now known as Deir el-Medina. Written records from the unusually well educated community offer fascinating descriptions of everyday activities

By Andrea G. McDowell



During the period known as the New Kingdom (1539–1075 B.C.E.), Egypt's southern capital city of Thebes developed into one of the great urban centers of the ancient world. The massive temple complexes of Karnak and Luxor were built during this time, and the two monuments still dominate the east bank of the Nile in the modern city, now called Luxor. The nearby Valley of the Kings, on the west bank of the Nile, contains some 60 tombs, including that of the pharaoh Tutankhamen. Hundreds of private tombs, some of them magnificently painted, also dot the landscape along the base of the cliffs on the Nile's west bank.

Although some of the paintings in the private monuments preserve tantalizing pictures of the luxurious life of the nobility, on the whole, the remaining temples and tombs tell us more about religious experience and beliefs concerning the afterworld than about the experiences of the living. Daily life is less well documented because, unlike the stone monuments we see today, the majority of homes, which were made of sun-dried brick, have succumbed to the damp of the floodplain, along with the furnishings and any written material that would have documented the lives of the literate few. On the westernmost edge of the sprawling ancient city, however, the remains of

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

DEIR EL-MEDINA (*above*) is located near the ruins of the city of Thebes. Deir el-Medina was home to the stonecutters and scribes who worked on the royal tombs in the Valley of the Kings. The artisans used flakes of limestone called ostraca as a cheap writing material for official and private records, letters, poems and sketches. Thousands of ostraca have been found in the remarkably well preserved village, shown below the way it may have looked some 3,000 years ago.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

A Lesson in Egyptian Literature

THE OSTRACON shown here bears an excerpt from the poem "Satire on the Trades," a classic of Middle Egyptian literature. The poem describes a variety of occupations, such as weaver, arrow maker and courier, that the author considered inferior to the laudable profession of scribe. The student who made this copy was apparently unfamiliar with the archaic language of the poem—written more than 700 years earlier—and garbled the original text. At the end of the lesson, the student wrote the date in brown ink.

ORIGINAL EXCERPT	STUDENT'S COPY OF EXCERPT
The courier goes into the desert,	*The courier goes into the desert,*
Leaving his goods to his children;	*Leaving his goods to his children;*
Fearful of lions and Asiatics,	*Fearful [of] lions and Asiatics,*
He knows himself [only] when	*What is it when he's in Egypt?*
he's in Egypt.	*When he reaches home distressed,*
When he reaches home at night,	*The journey has divided him.*
The march has worn him out;	*While he comes forth [from] his*
Be his home of cloth or brick,	*cloth [or] brick,*
His return is joyless.	*He will not come it in joy.*

Translation by Miriam Lichtheim, from *Ancient Egyptian Literature I* (University of California Press, 1973)

—Third month of winter season, day 1

THE AUTHOR

ANDREA G. McDOWELL, who holds a J.D. and a Ph.D., has written extensively on law and other aspects of life in Deir el-Medina. She taught Egyptology at Leiden University, the University of Oxford (where she was a junior research fellow at Somerville College) and Johns Hopkins University before attending Yale Law School. She is now an associate professor of law at Seton Hall University School of Law. Her current research is on law in the California gold rush and, more generally, on the origins and development of property rights.

one small community escaped the general disintegration. This is the village now called Deir el-Medina, the home of the craftsmen who cut and decorated the royal tombs in the Valley of the Kings.

Lying in an arid and relatively isolated region, the site remains remarkably well preserved: houses and chapels are still standing to a height of up to two meters in some places. Archaeologists in the first half of this century found a wealth of religious monuments and household possessions among the effects, as well as intact tombs containing coffins, furniture and clothing. And across the entire site but especially in the town's garbage dumps, researchers recovered tens of thousands of written documents, most of them dating from the period between 1275 and 1075 B.C.E. Some of the texts are on sheets of papyrus, but most are on shards of pottery or smooth, white flakes of limestone, known as ostraca, that served as a sort of scrap paper for the community.

These writings bring the villagers to life. In them, one finds government records, love poems and private letters describing family strife, health concerns and legal disputes. The documents also offer some insight into the education system of ancient Egypt—a topic I have investigated at length. The wealth of texts from the site suggests that in some periods of its history, most men in the town could read and write. (Scholars do not know whether many women in Deir el-Medina were literate. Women in the village did exchange letters, but they may have dictated their thoughts to men.) This high literacy rate stands in stark contrast to the situation throughout the rest of ancient Egyptian society, which during the New Kingdom period had a total literacy rate hovering around only 1 or 2 percent. The ostraca illuminate how the villagers achieved such an impressive level of education.

"Bring Honey for My Eyes"

BEFORE WE LOOK more closely at the educational system in Deir el-Medina, however, a quick survey of some of the recovered ostraca will help reconstruct life in the village and the context in which this extraordinary rate of literacy developed. As the large number of administrative documents suggests, the Egyptians of this period were obsessive bureaucrats, keeping careful records of the tools issued to the men laboring on the tombs, the rations delivered to the gang, the overall progress of the work and almost every other detail that could be quantified.

The residents' private jottings are even more varied. Many are purely practical: receipts for purchases or records of

preceding pages: TOMO NARASHIMA *(illustration)* AND O. LOUIS MAZZATENTA *National Geographic Image Collection (photograph); this page:* MEDIA SERVICES, HUNTERIAN MUSEUM, UNIVERSITY OF GLASGOW

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

TOOLS OF THE TRADE included brushes of all sizes, a pot of red pigment and raw minerals. Scribes used these tools to paint the figures and hieroglyphs that decorated the royal tombs.

legal battles (the villagers were avid litigators). The most intriguing texts are perhaps the personal letters, which take the reader straight into the world of New Kingdom Egypt. In one such missive, a father, Pay, writes to his son about his eye disease—apparently one of the hazards of tomb building because of the dust, bad lighting and flying splinters of stone associated with the task:

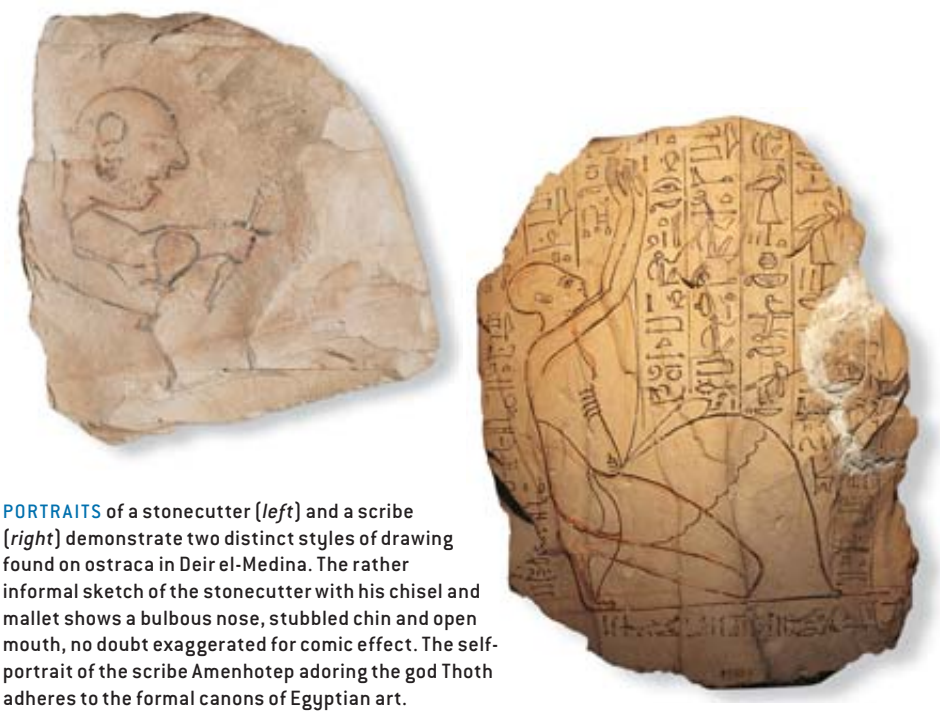
> *The draftsman Pay says to his son the draftsman Pre[emhab?]: Do not turn your back on me; I am not well. Do not c[ease] weeping for me, because I am in the [darkness(?) since] my lord Amon [has turned] his back on me.*
>
> *May you bring me some honey for my eyes, and also some ocher which is made into bricks again, and real black eye paint. [Hurry!] Look to it! Am I not your father? Now, I am wretched; I am searching for my sight and it is not there.*

Pay's lament is not surprising: blindness would have completely incapacitated a draftsman, who painted the figures and hieroglyphs inside the tombs. Descriptions of the mixture of honey, ocher and black eye-paint that Pay requested appear in specialized medical papyri, suggesting that it was a common remedy. Indeed, honey does have antiseptic properties, and ocher, an ingredient in many other prescriptions of the day, feels cool on the eyelids and was thought to reduce swelling. Because so many workmen suffered from this type of eye disease, this treatment may have been well known, and Pay was ordering it for himself. Alternatively, Pay could have been asking his son to fill a doctor's prescription.

Roughly half the texts found at Deir el-Medina are religious or literary pieces. Copies of most of the "classics" from ancient Egyptian literature have been found at the site; in some cases, ostraca from the village provide the only surviving example of a work. These classics were a fundamental part of a student's education: thousands of school texts bear extracts from the masterpieces of Middle Kingdom (roughly 2000–1640 B.C.E.) literature, composed in a language as remote from the vernacular of the students as the English of Chaucer is from ours. Furthermore, many of the villagers were authors in their own right, composing instruction texts, hymns and letters. For example, the scribe Amennakhte wrote a poem in praise of the cosmopolitan city of Thebes, located just across the Nile:

> *What do they say to themselves*
> *in their hearts every day,*
> *those who are far from Thebes?*
> *They spend the day*
> *dreaming [?] of its name, [saying]*
> *"If only its light were ours!"...*
> *The bread which is in it is more tasty*
> *than cakes made of goose fat.*
> *Its [water] is sweeter than honey;*
> *one drinks of it to drunkenness.*
> *Behold, this is how one lives*
> *in Thebes!*
> *The heaven has doubled [fresh]*
> *wind for it.*

The villagers held knowledge of and ability in the literary arts in high esteem, as indicated on a papyrus found in the



PORTRAITS of a stonecutter (*left*) and a scribe (*right*) demonstrate two distinct styles of drawing found on ostraca in Deir el-Medina. The rather informal sketch of the stonecutter with his chisel and mallet shows a bulbous nose, stubbled chin and open mouth, no doubt exaggerated for comic effect. The self-portrait of the scribe Amenhotep adoring the god Thoth adheres to the formal canons of Egyptian art.

MINISTRY OF CULTURE AND ENVIRONMENT, EGYPTIAN MUSEUM, TURIN (*top*); EGYPTIAN MUSEUM, CAIRO (*left*); FITZWILLIAM MUSEUM, UNIVERSITY OF CAMBRIDGE (*right*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

STUDENT'S DRAWING of a royal portrait on this ostracon has been corrected in white by his teacher. In Deir el-Medina, young men had individual tutors who educated them in reading, writing and culture.

OVENS for baking stood in the kitchen areas behind the houses in Deir el-Medina. In this sketch, the words "blowing into the oven" can be seen in the text to the left of the woman.

archives of a resident scribe. In this extract, the writer presents an unusual tribute to learning: whereas other documents tend to emphasize primarily writing skills and familiarity with classical literature, this description of the profession of scribe emphasizes authorship, the creation of texts and the fame that can come after death. In short, the writer appeals to the great Egyptian aspiration for immortality:

> *As for the learned scribes from the time that came after the gods—those who foretold the things to come—their names endure forever, although they have gone, having completed their lifetimes, and their relatives are forgotten.*
>
> *They did not make for themselves pyramids of copper with tombstones of iron. They were unable to leave an heir in the form of children [who would] pronounce their name, but they made for themselves an heir of the writings and instructions they had made.*

Importance of Education

THE EXCEPTIONAL RATE of literacy among the workmen at Deir el-Medina no doubt developed because the many skilled artisans needed an understanding of hieroglyphs for their job in the royal tombs. Early in the history of the village, the pharaohs' tombs contained only simple copies of the guides to the afterworld, written in cursive script with accompanying vignettes drawn in stick figures. But at the end of the 14th century B.C.E., elaborately carved and painted scenes began to appear in tombs. At the same time, the literacy rate in the town rose sharply, as evidenced by the increase in the number of texts written after this period.

The king Horemheb, who ruled from 1319 to 1292 B.C.E., introduced these painted reliefs to the Valley of the Kings. The more elaborate projects of Horemheb and later kings required a team of draftsmen to do the initial drawings and the final paint job; because the tomb paintings included large amounts of hieroglyphic texts, these workers had to be literate.

Perhaps more surprising was that at least some of the men responsible for the grueling task of carving the tomb out of the mountainside were also literate, even though their job did not call on such skills. Ambition may have motivated these laborers: education and literacy offered the keys to a good career in Egypt, separating the artisan class from the peasants, and the skills would have stood the workers in good stead had there been no job for them among the tomb builders. In addition, the culture of learning in the village may have also been a powerful stimulus, encouraging young people to study to keep up with their peers.

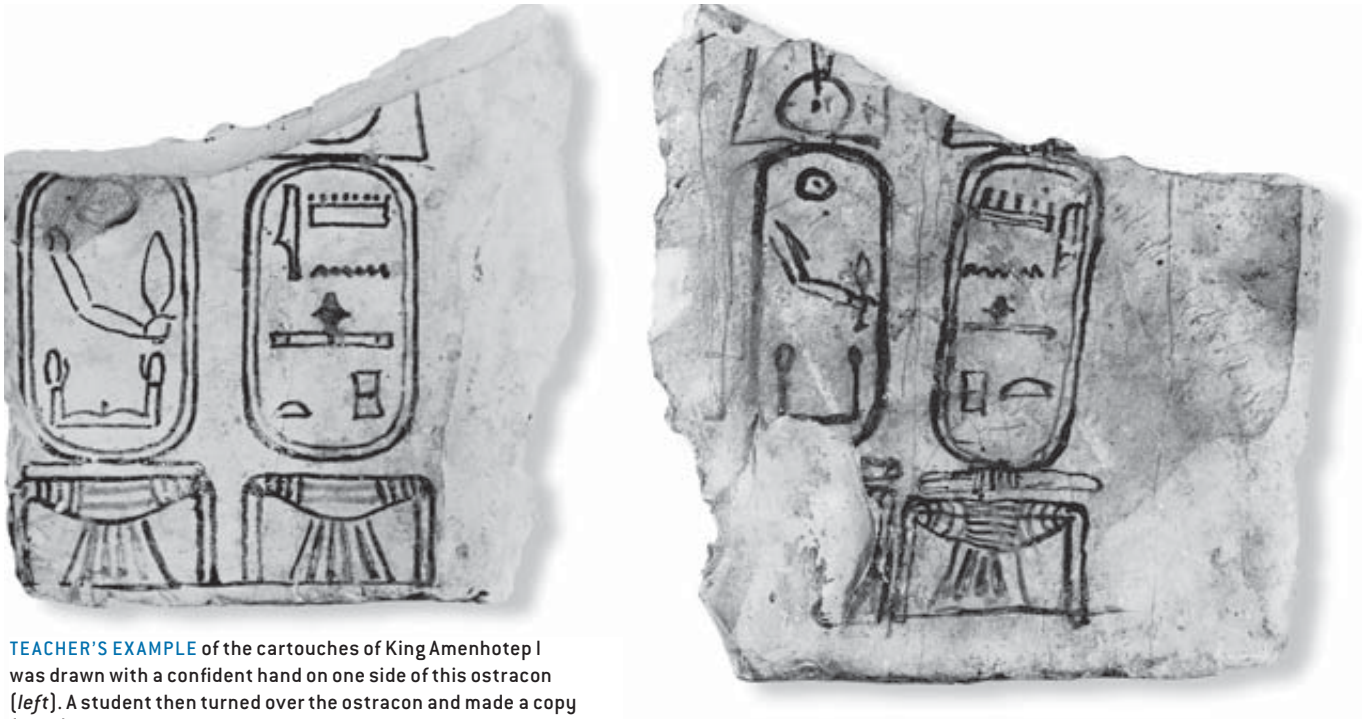
Egyptologists can glean numerous details from the ostraca found in Deir el-Medina, but unfortunately, we still know little of how the residents actually learned to read and write. Egyptian texts of the New Kingdom refer to schools only incidentally, indicating that they existed and that relatively young children attended them. For example, a short story found in the village describes the experiences at school of its young hero, a boy whose mother is not married:

> *He was sent to school and learned to write very well. He practiced all the arts of war and he surpassed his older companions who were at school with him. Then his companions said to him: "Whose son are you? You don't have a father!" And they reviled him and mocked him: "Hey, you don't have a father!"*

But scholars have no evidence for an actual school at Deir el-Medina—no textual references to a school building, no structure that looks like a schoolroom, and no concentrations of student exercises that might signify a teaching area. In fact, we have no clues about how the workmen's children

FRENCH INSTITUTE OF EASTERN ARCHAEOLOGY, CAIRO (*left*); EGYPTIAN MUSEUM, LEIPZIG UNIVERSITY (*right*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.



TEACHER'S EXAMPLE of the cartouches of King Amenhotep I was drawn with a confident hand on one side of this ostracon (*left*). A student then turned over the ostracon and made a copy (*right*), in the process reversing some of the signs.

learned their skills of reading and writing.

Some of the ostraca left behind do give a somewhat more complete picture of what could be called secondary education—additional training in reading, writing and culture. Many of the documents found in the village are obviously exercises for advanced students, occasionally signed with the names of the student and teacher. Some of the writings bear a date marking the end of a day's lesson; some texts include several such dates, suggesting that a student used a single ostracon for several lessons.

From the various signatures on the ostraca, it is clear that fathers or grandfathers often supervised their sons' or grandsons' education, although on some occasions, fathers—even literate ones—might send their sons to someone of a higher rank for advanced training. (One signature, unfortunately badly preserved, may be a female student's, so at least one woman might have received her education in this fashion.) Pupils would have been from any station in life, including not only the future leaders of the community but also some boys who would never rise above the rank of stonecutter. Teachers consistently came from higher classes, however: the instructors mentioned in the ostraca were primarily scribes, draftsmen or chief workmen.

The students seem to have fit their lessons around their jobs at the tomb, as indicated by the dates in the ostraca—for example, texts often contain multiple dates separated by several days, indicating that there was usually time between lessons when both the instructor and pupil were presumably at work. Nevertheless, there was plenty of time for learning. Workers had many days off, especially as the tomb neared completion toward the end of a pharaoh's reign. During the final stages of construction, they might spend no more than one day out of four in the Valley of the Kings.

The education system in Deir el-Medina differed from that in other cities and towns around Egypt, most notably in who learned to read and write. Furthermore, the writing materials used and the time available for instruction also stand in contrast to practices elsewhere. Student exercises found in other locations were composed on reused papyrus—readily available to those in official positions—and appear to be the handiwork of young apprentices who were being groomed for government service. These students pursued their studies daily and managed to complete several pages of papyrus a day.

Although some aspects of the schooling system in Deir el-Medina diverged from the typical approach to education, the residents of the village apparently agreed with widespread notions about what should be taught and why. Teachers in this workmen's village might train stonecutters in between days on the job, writing on flakes of limestone (the material most available to them), but they still instructed their students in the great classics of Egyptian literature, with the goals of passing on wisdom and ensuring a successful career. As one village scribe wrote to a young pupil: "Set your heart very firmly on writing, a useful profession for the one who does it. Your father had hieroglyphs, and he was honored in the streets." SA

MORE TO EXPLORE

A Community of Workmen at Thebes in the Ramesside Period. Jaroslav Černý. French Institute of Eastern Archaeology, Cairo, 1973.

The Tomb-Builders of the Pharaohs. Morris Bierbrier. British Museum Publications, London, 1982.

Letters from Ancient Egypt. Translated by Edward F. Wente. Edited by Edmund S. Meltzer. Scholars Press, 1990.

Village Life in Ancient Egypt. A. G. McDowell. Oxford University Press, 1999.

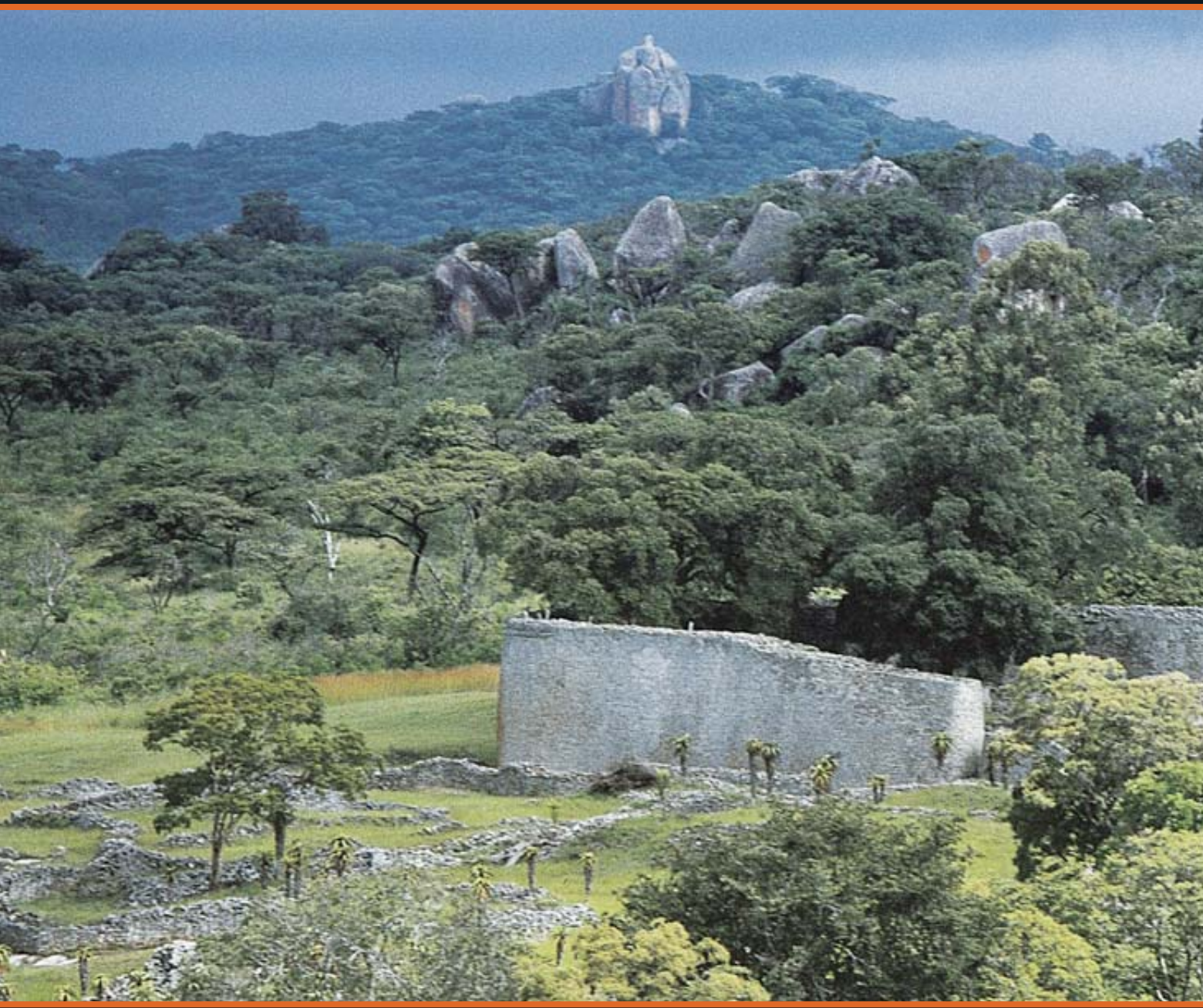
MEDELHAVSMUSEET, MUSEUM OF MEDITERRANEAN AND NEAR EASTERN ANTIQUITIES, STOCKHOLM

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Zimbabwe

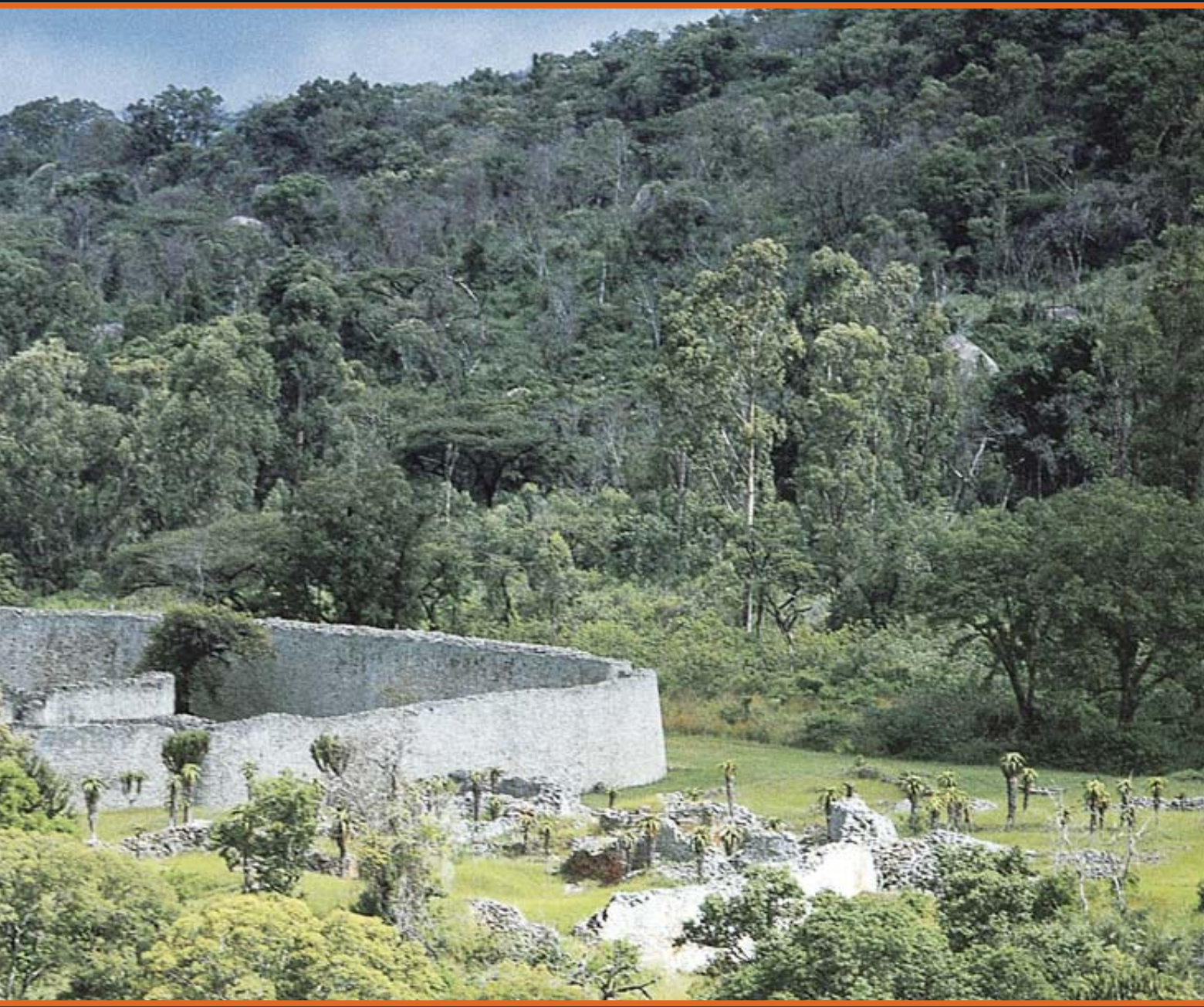
Great Zimbabwe

By Webber Ndoro



COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

For centuries, this ancient Shona city stood at the hub of a vast trade network. The site has also been at the center of a bitter debate about African history and heritage



GREAT ZIMBABWE RUINS stand on the Zimbabwe plateau, testament to a powerful culture that flourished between the 12th and 17th centuries. In the center is the elliptical building known as the Great Enclosure. The Hill Complex, another built-up area of Great Zimbabwe, is visible at the upper left.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

SOPHISTICATED STONEWORK and curved walls are hallmarks of Great Zimbabwe, as seen in the conical tower (*a*), the elegant rounded steps (*b*), the chevron pattern on the walls of the Great Enclosure (*c*) and the inner passage of the Great Enclosure (*d*). Other features, such as the stone protrusions in this courtyard (*e*), remain entirely mysterious.

On the southern edge of the Zimbabwe plateau in the watershed between the Zambezi and the Limpopo rivers sits the largest and loveliest archaeological site in sub-Saharan Africa. With its high conical tower, its long, curved stone walls and its cosmopolitan artifacts, Great Zimbabwe attests to the existence of a thriving city that may have dominated trade and culture throughout southern Africa sometime between the 12th and 17th centuries. Its unique architecture and sculpture—particularly the enigmatic birds carved from soapstone—bespeak a rich history, one that archaeologists continue to piece together today. The country of Zimbabwe—formerly Rhodesia, until its independence from England in 1980—was named for this site.

Like many ancient cities, Great Zimbabwe has been shrouded by legend. In the 1500s Portuguese traders visiting Angola and Mozambique—where they established colonies—wrote of a kingdom in the interior of Africa. Their descriptions offered many Europeans the promise of King Solomon's mines, for according to the Bible, Solomon would send to Ophir for his gold. In *Paradise Lost,* John Milton situates Ophir somewhere near the Congo and Angola. This powerful myth of the city of Ophir, populated by Semitic people, shaped the later cultural and historical interpretations of Great Zimbabwe. The fable is, in large part, the reason so many archaeological mysteries remain about the site. Because whereas the story of Great Zimbabwe is ultimately that of early Shona culture and the African Iron Age, it is also a tale of colonialism and of often shoddy, politically motivated archaeology.

Masterful Stonework

CONSTRUCTED BETWEEN 1100 and 1600, Great Zimbabwe seems not to have been designed around a central plan but rather to have been altered to fit its changing role and population. Its scale is far larger than that of similar regional sites—including Danamombe, Khami and Naletale (in Zimbabwe), Domboshaba and Majande (in Botswana), Manikweni (in Mozambique) and Thulamela (in northern South Africa)—suggesting that Great Zimbabwe was the area's economic and political center. Because it is situated on the shortest route between the northern gold fields, where inland rivers were panned for the precious metal, and the Indian Ocean, the rulers of Great Zimbabwe most likely regulated the thriving medieval gold trade.

Great Zimbabwe covers 1,779 acres, and the central area comprises three main built-up areas: the Hill Complex, the Great Enclosure and the smaller Valley Ruins. The Hill Complex, dubbed the Acropolis by Europeans, forms the oldest part of the site; evidence hints that farmers or hunters may have encamped there as early as the fifth century. From its position on the rocky, 262-foot-high hill, the Hill Complex's oval enclosure—about 328 feet long and 148 feet wide—would have allowed its inhabitants to see potential invaders. The outer wall, which stands nearly 37 feet high, would also have afforded good protection. Inside the walls, as inside all the other enclosures, stand *daga* houses, curved, hutlike structures made of Africa's most common building material: dried earth, mud and gravel.

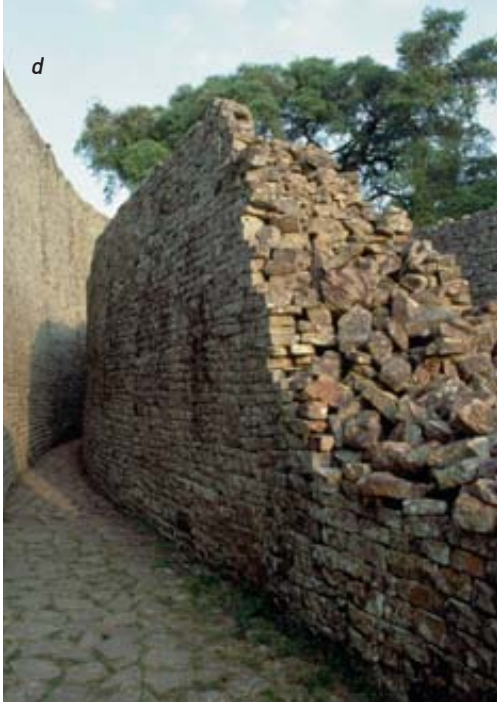
Below the Hill Complex sits the most stunning of Great Zimbabwe's structures, the Great Enclosure, or Elliptical Building. Called *Imbahuru,* meaning "the house of the great woman" or "the great house," by the Karanga-speaking people who lived there during the 19th century, the Great Enclosure was built at the height of Great Zimbabwe's power. (Karanga is the most common dialect of Shona and is spoken by the inhabitants of south-central Zimbabwe.) The enclosing wall is 800 feet long and stands 32 feet high at some places; an estimated one million blocks were used in its construction. An inner wall runs along part of the outer wall, creating a narrow, 180-foot-long passageway.

The function of the Great Enclosure is not known, although it is thought to have served as a royal palace. Because of the presence of grooves in the walls (perhaps representing the female anatomy) and of phallic structures, some historians have postulated that the compound was used for adolescent initiation rites or for other important ceremonies. It may have also housed the many wives of the ruler. The great conical tower, which stands 30 feet high and is 18 feet in diameter at the base, appears not to have been used for any particular purpose and may have served a merely symbolic function.

In addition to the Hill Complex and

preceding pages: JASON LAURÉ; *this page:* CHARLES AND JOSETTE LENARS *Corbis* (*a*); DAVID REED *Corbis* (*b*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.



ROBERT HOLMES *Corbis* (*c* and *e*); CORDAIY PHOTO LIBRARY LTD. *Corbis* (*d*)

the Great Enclosure, Great Zimbabwe is made up of the smaller Valley Ruins. This series of compounds stands in the valley between the two larger structures. The walls seem to be youngest here, suggesting that these structures were built as the population expanded and Great Zimbabwe needed more residential space.

Great Zimbabwe is unusual not only in its size but in its stonework. Many of the structures are made of rectangular blocks cut from nearby granite outcroppings. The city's name derives from the Shona term *dzimbabwe,* meaning "houses of stone." The blocks, set in layers without mortar, form stable freestanding, curved walls that are often about twice as high as they are wide. Although round, buttresslike structures rest along the base of many walls, they have no supportive role. Some archaeologists speculate that these curved extensions may have served to soften the approach to a doorway, or to have made passageways more complicated to navigate or perhaps even to have hidden rooms from direct view. They also may have served to control access to some areas, because people could have moved into the area in single file only.

The stonework is, in certain places, astonishingly sophisticated: rounded steps grace some of the entrances, and chevron designs decorate some of the walls. The walls are also punctuated by drains and occasionally by four-foot-wide doorways, some of which had wood lintels.

A Mysterious Culture

OUR KNOWLEDGE of the people of Great Zimbabwe is complemented by what we know about the site of Mapungubwe, which appears to have been the center of Shona civilization around 1000. The largest Mapungubwe settlements, found in the Shashi-Limpopo area, are very similar to Great Zimbabwe. Wealth was apparently based on cattle production, ivory trade and gold. The Mapungubwe culture spread into western parts of Zimbabwe as the presence of Leopard's Kopje pottery (in Mapungubwe style) attests. With the rise of Great Zimbabwe, it appears that trade shifted and Mapungubwe declined as an important center, becoming abandoned just as Great Zimbabwe prospered.

Artifacts unearthed at Great Zimbabwe have pointed to the social and cultural organization of the settlement, and they have distinguished it from other Iron Age sites. In particular, a group of soapstone birds, many of them 14 inches high and sitting atop three-foot-tall columns, is unlike any sculpture found elsewhere. Each bird has a different pattern or marking; none is identifiable as a local creature. Because of the regard contemporary Shona people hold for their dead and because some Shona tribes use iron rods to mark tallies of their dead, some archaeologists have speculated that the avian icons indicate aggregates of ancestors used in rituals.

Other artifacts indicate that Great Zimbabwe was well established as a trading community by the 14th century. Objects from distant lands made their way to Great Zimbabwe: Syrian glass, Chinese celadon dishes (mostly from the Ming Dynasty, 1368 to 1644), Persian faience bowls, coral, bronze bells and an iron spoon—a utensil not used by the Shona. There is no blue-and-white Chinese porcelain, which became widespread during the mid-15th century; its absence suggests that Great Zimbabwe's economic importance was less by that time. Indeed, it does appear that the site was largely empty by 1700.

THE AUTHOR

WEBBER NDORO is currently at ICCROM (the International Center for the Study of the Preservation and Restoration of Cultural Property), where he is project manager for the Africa 2009 Program. He taught heritage management at the University of Zimbabwe. Ndoro holds degrees in archaeology from the University of Cambridge, architectural conservation from the York University in England and a Ph.D. in heritage management from Uppsala University in Sweden. He was conservator for the Great Zimbabwe World heritage site and coordinator of the Monuments Program from 1988 to 1994.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

SHONA BIRDS, often placed atop pillars, have been found only at Great Zimbabwe. These soapstone carvings do not resemble any local species; archaeologists and historians have been unable to determine their significance.

There are several reasons Great Zimbabwe may have been abandoned. By the late 1600s the northern rivers had been panned clean, and the gold trade began to move west. No longer centrally located, the city may not have been able to thrive when revenue and trade dried up. Another possibility is that the population became unsustainable. By some estimates, Great Zimbabwe had between 10,000 and 17,000 residents at its peak—a population equivalent to that of medieval London. (Other estimates are more conservative, placing the populace at a maximum of 2,000.)

The area may have become devegetated as huge herds of cattle grazed it or as it was extensively farmed; recent environmental data suggest that a succession of severe droughts caused people to disperse. Or there may have been some other impetus, such as war, although there is no evidence besides minimal weaponry to support this argument. More archaeological clues, further digs at Great Zimbabwe and excavations at other Iron Age sites are needed to resolve the question of decline.

Plunder and Misappropriation

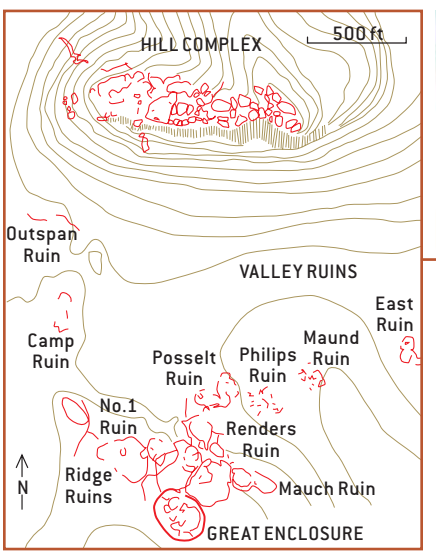
LARGELY ABANDONED for 200 years or so, Great Zimbabwe was probably used only irregularly for religious ceremonies—as it is again today—until the late 1800s. It was then that Europeans arrived, lured by visions of gold from King Solomon's mines, and it was then that the archaeological record became so damaged as to become largely indecipherable.

A German explorer, Karl Mauch, was first to arrive, in 1871. He befriended another German, Adam Render, who was living in the tribe of Chief Pika, a Karanga leader, and who led him to Great Zimbabwe. (Had he known the outcome, Render, who was married to two tribeswomen and well integrated, might have steered Mauch into the Zambezi River.) On seeing the ruins, Mauch concluded very quickly that Great Zimbabwe, whether or not it was Ophir, was most certainly not the handiwork of Africans. The stonework was too sophisticated, the culture too advanced. It looked to Mauch to be the result of Phoenician or Israelite settlers. A sample of wood from a lintel bolstered Mauch's rapid assessment: it smelled like his pencil; therefore, it was cedar and must have come from Lebanon.

Mauch's visit was followed by one from Willi Posselt, a looter, who lugged off a carved soapstone bird and hid others so he could return for them later. Posselt was followed by a series of visitors, some of whom worked for W. G. Neal of the Ancient Ruins Company, which had been created in 1895. Cecil Rhodes, founder of the British South Africa Company, gave Neal a commission to exploit all Rhodesian ruins. Neal and his rogues pillaged Great Zimbabwe and other Iron Age sites, taking gold and everything of value, tearing down structures and throwing away whatever was not valuable to them (pottery shards, pots, clay figurines).

The first official archaeologist to visit the site, James Theodore Bent from Britain, had added to the confusion in 1891 by digging around the conical tower in the Great Enclosure—thereby completely destroying the stratigraphy and making it impossible for later archaeologists to make sense of its age. Bent also threw away clay and metal artifacts, including Persian and Arab trade beads, as insignificant. The archaeologist concluded that Great Zimbabwe had been built by a local "bastard" race—bastards because their fathers must have been white invaders from the north—because, as Rhodes and most European settlers maintained, native Africans could never have constructed Great Zimbabwe themselves.

A 1902 report written by Neal and a journalist named Richard N. Hall reiterated Bent's conclusions: the architecture was clearly Phoenician or Arabian. This attitude was pervasive in colonialist Africa: the continent had no



ZIMBABWE, formerly Rhodesia, lies in southeastern Africa and has some 35,000 registered archaeological sites. The ruins of Great Zimbabwe are by far the largest of these, covering 1,779 acres.

ROBERT HOLMES *Corbis*; JOHNNY JOHNSON (*map*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

history, no sophistication; its people and tribes were unchanging, unable to develop, culturally barren.

Archaeologists who suggested otherwise were not well received. In 1905 David Randall-MacIver, an Egyptologist who had studied under the famous William Matthew Flinders Petrie, excavated at the site and uncovered artifacts very similar to the ones being used by Shona, or Karanga, people living in the vicinity. By turning to indigenous people for cultural clues and interpretation rather than just for labor, Randall-MacIver was indeed doing something unprecedented. Had any other investigators of the time drawn on the lore or knowledge of the local people, many of the questions about Great Zimbabwe might well have been answered.

The continuity of artifacts suggested to Randall-MacIver that the site had been built by people whose culture was similar. He also demonstrated that the Arab and Persian beads were no older than 14th or 15th century and thus did not date back to biblical times and King Solomon. And he argued that the stonework was not at all Arabic, because it was curved and not arranged in geometric or symmetric patterns. Randall-MacIver concluded that native Africans had built Great Zimbabwe.

Two subsequent researchers held the same opinion. In 1926 J. F. Schofield reiterated Randall-MacIver's conclusions, and in 1929 Gertrude Caton-Thompson did the same. Her excavations of the undisturbed Maund Ruin—which lies at the opposite end of the valley from the Great Enclosure—again supported the theory of indigenous construction. Caton-Thompson's detailed drawings and careful stratigraphy have been crucial in piecing together what little is known about Great Zimbabwe.

Despite the mounting evidence and archaeological testimony, most European settlers in Rhodesia rejected the record. From 1965 until independence in 1980, the Rhodesian Front censored all books and other materials available on Great Zimbabwe. This party, established by then prime minister Ian Smith to prevent Africans from gaining power, was based on a system of apartheid. Archaeologists, such as the noted Peter S. Garlake, who were vocal about the native origin of Great Zimbabwe were imprisoned and eventually deported. Africans who took the same view lost their jobs. Displays at the site itself were censored as well, although it hardly mattered because they were in English, and locals were not allowed to use the premises for any ceremonies.

PAUL ALMASY *Corbis*

GREAT ENCLOSURE, shown here from one side, perhaps served as the royal quarters of Great Zimbabwe. The structure was built during the city's heyday; its surrounding wall is 800 feet long and comprises an estimated one million stone blocks.

Reclaiming the Past

TODAY GREAT ZIMBABWE is a symbol of African cultural development. Popular books have made the monument somewhat more accessible to the people of Zimbabwe. Yet, at the same time, Great Zimbabwe remains largely inaccessible. Because of past archaeological mistakes, much of the history of the site is elusive. Given the condition of contemporary archaeology in southern Africa, there is little chance this will change soon.

The two archaeologists who are currently stationed at the site are responsible not only for the preservation of the decaying monument but for dealing with visitors and maintenance—and the 5,000 other sites that are under their jurisdiction as well (out of a total of 35,000 recorded sites in Zimbabwe). Although the ruins are protected by the National Museums and Monuments of Zimbabwe and were designated a World Heritage Site by UNESCO, only two conservators and fewer than 10 archaeologists are available in Zimbabwe to study and look after all the archaeological sites, including Great Zimbabwe.

The situation in other sub-Saharan countries is no better. According to Pierre de Maret of the Free University of Brussels, less than $150,000 is spent annually on archaeology in 10 sub-Saharan countries—and there are a mere 20 professional archaeologists among them. The sale of African objects abroad, however, reaches into the millions of dollars every year.

It is clear that cultural legacies are being lost as monuments decay and artifacts are taken out of the various countries. If contemporary cultures, fragmented and ruptured by centuries of colonialism, are going to be able to piece together and to reconnect with their severed past, archaeology will need to assume a more important place in African society. Great Zimbabwe is so important not simply because of its masterful masonry but because it is a cultural clue that survived and has been reclaimed. Now it needs to be fully interpreted and placed within the larger context of sub-Saharan history, a context that still lies hidden. SA

MORE TO EXPLORE

Zimbabwe: A Rhodesian Mystery. Roger Summers. Thomas Nelson and Sons, 1963.

Great Zimbabwe. Peter S. Garlake. Stein and Day, 1973.

The Shona and Zimbabwe, 900–1850. D. N. Beach. Africa, 1980.

Dzimbahwe: Life and Politics in the Golden Age, 1100–1500 A.D. Ken Mufuka. Harare Publishing House, 1983.

Culture and Development in Africa. Edited by Ismail Serageldin and June Taboroff. International Bank for Reconstruction and Development/World Bank, 1994.

Uncovering the Past: A History of Archaeology. William H. Steibing, Jr. Oxford University Press, 1994.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Peru

Precious Metal Objects of the MIDDLE SICÁN

A Peruvian culture older than the Incas made unprecedented use of gold and other metals. Studies of Sicán metalworking techniques offer hints about this mysterious society

By Izumi Shimada and Jo Ann Griffin

Old ceremonial masks and knives are popular symbols of pre-Hispanic Peruvian culture. Examples adorn the covers of books on Peru and serve as emblems for some Peruvian institutions. These precious metal artifacts are often attributed, even by knowledgeable persons, to the Incas or to their coastal rivals, the Chimú. Yet many of them are not Incan or Chimú at all: they were created much earlier by the Sicán culture, which was centered in the Lambayeque region of northern Peru and flourished from the ninth to the 14th centuries.

The Middle Sicán era, between 900 and 1100 C.E., produced enormous quantities of precious metal artifacts, many showing extraordinarily high craftsmanship. We and our colleagues from several disciplines have scrutinized the metalwork from one Middle Sicán trove in an attempt to reconstruct the technology and organization of precious metal production and to define the meaning of those products within the culture. We determined that the scale and the range of metal use by the people of the Middle Sicán was unprecedented in the pre-Hispanic New World. That culture's extensive production of arsenical copper ushered the bronze age into northern Peru. Gold alloys were the most prestigious media for political, social and religious expression. In fact, we suspect that metallurgical production was a prime mover of Middle Sicán cultural developments.

Ambiguity and ignorance have traditionally shrouded precious metal arti-

POMA NATIONAL Historical Sanctuary is located on the northern coast of Peru. The first tomb of a member of the Middle Sicán ruling class to be scientifically excavated is at Huaca Loro, an adobe platform mound within the Poma sanctuary. Excavation revealed myriad precious metal objects and much new information about what had been a little-known pre-Inca culture.

LUCY READING-IKKANDA (*map*); YUTAKA YOSHII (*opposite page*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

FULLY RESTORED MASK and headdress (about one meter in height) offer stunning evidence of a sophisticated group of craftsmen and the society that supported them.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Excavating a Middle Sicán Tomb

TOMB AT HUACA LORO held the remains of a member of the Sicán elite, a man 40 to 50 years of age (*1*). He was accompanied by two young women and two children, who had apparently been sacrificed. The area enclosed by the rectangle shows the body of this elite individual, who was buried in a seated, inverted position. His head had been detached from his body, rotated 180 degrees and bent back so that the top pointed upward. His face was covered by a large gold mask (*2*), which is also shown shortly after removal from the tomb while it was still extensively deformed and spotted with soil (*3*). During the restoration process (*4*), patches of nylon fabric were placed over parts of the mask to prevent the cinnabar with which it had been painted from flaking off. In addition to the bodies and their elaborate coverings, the tomb contained 1.2 tons of diverse grave goods (*5*), most of precious metal.

facts of the Middle Sicán. Almost all of those in private and public collections were looted from tombs within what is today the Poma National Historical Sanctuary in the mid-La Leche Valley, about 800 kilometers north of Lima. The modern period of intensive grave robbery began in the 1930s. Treasure hunters sank vertical prospecting pits into likely spots, then dug horizontal tunnels outward. With the discoveries of more rich tombs, the extent of the looting continued to increase through the 1940s and 1950s. It culminated in the late 1960s, when a bulldozer was employed for a year to remove the surface soil so that outlines of the tomb pits could be seen more easily. Looting took place sporadically until the mid-1970s, effectively hindering any long-term scientific study of the regional prehistory. When one of us (Shimada) began fieldwork in 1978, he counted more than 100,000 looters' holes and hundreds of long bulldozer trenches on aerial photographs of the Poma sanctuary.

The lack of contextual information for those looted artifacts greatly limits understanding of their sociopolitical, religious and economic significance. Moreover, looters and collectors often took questionable and undocumented measures to "restore" stolen artifacts. Pigments, feathers and ancient tool marks on gold objects could have been removed by careless cleaning. "Missing" inlay pieces or bangles were often arbitrarily replaced. As a result, the appearance of objects cannot be taken at face value, which limits the information that can be drawn from them. Any attempt to understand the objects, their cultural significance and the techniques used in their manufacture is therefore best founded on those artifacts scientifically recovered from intact tombs.

Sampling a Tomb

THE OPPORTUNITY to gain just such an understanding came about with the first scientific excavation of the tomb of a member of the Middle Sicán elite at Huaca Loro, an adobe platform mound in the Poma sanctuary. The tomb was apparently one of a string left by the Middle Sicán, some of which had already been looted, along the east and south bases of Huaca Loro. Shimada recognized it during a survey of Batán Grande in 1978. He planned its excavation over the next 10 years as part of his broader sampling of Sicán tombs for the elucidation of that culture's social organization. Preparations included assembling a group of specialists and piecing together a Sicán cultural chronology, as well as the performance of other background research.

In particular, Shimada needed to make certain that the groundwater lev-

YUTAKA YOSHII (*2, 4*); IZUMI SHIMADA (*1, 3, 5*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

3

4

5

el was sufficiently low to allow safe excavation. He also gave a series of public talks on the scientific value of the planned tomb excavation to local residents, who were weary of tomb looting. The chamber was finally excavated, under Shimada's supervision, by the Sicán Archaeological Project between October 1991 and March 1992.

The central person buried in the tomb was a 40- to 50-year-old man who had been one of the elite. He was accompanied by the bodies of two women and two children who apparently had been sacrificed. The six-month excavation yielded approximately 1.2 tons of diverse grave goods packed in a burial chamber roughly three meters on a side at the bottom of an 11-meter vertical shaft. By weight, metal objects and scrap account for nearly three quarters of the grave goods. Most of the objects, according to a systematic analysis of some 1,000 samples by Adon Gordus, professor of chemistry at the University of Michigan at Ann Arbor, appear to be 12- to 18-karat gold-silver-copper alloys roughly equivalent to the gold commonly used today for jewelry. Some objects and nearly all the scrap are *tumbaga,* gold-silver-copper alloys that are high in copper and have a few to 10 karats.

Arranged concentrically, the objects surrounded the body of the man, which was thoroughly painted with cinnabar (an intensely red paint made up of mercuric sulfide and a binder). The body was seated and placed in an inverted position [*see (1) in box on opposite page*]. The head, with its three sets of attached ear ornaments and its large gold mask, was detached from the body and rotated 180 degrees so that his head was right side up and facing west. A mantle (its cloth long since decayed) onto which nearly 2,000 gold foil squares had been sewn was laid on the floor underlying the inverted body. Placed on, around and underneath the body were a staff with gold and *tumbaga* ornaments on top of a wooden shaft, a gold headdress with a sculptural representation of an animal head, a pair of gold shin covers, a pair of meter-long *tumbaga* gloves (one holding a gold cup with a silver rattle base), a gold ceremonial knife (or *tumi*) and a cluster of six magnificently made pairs of gold earspools. His chest was bedecked with a nearly 10-centimeter-thick layer of beads (made of sodalite, amethyst, quartz crystal, turquoise, amber, fluorite, calcite, shell and other materials). Farther away, near the edges of the chamber, were about 500 kilograms of *tumbaga* scrap and more than 250 kilograms of arsenical copper implements.

By far the most impressive find within the tomb is Gold Cache 1, which we discovered at the northwest corner of the burial chamber. Inside a rectangular box lined with woven mats were at least 60 major objects, most of gold sheet, the balance of silver or *tumbaga*. This cache contains a peculiar mixture of ritual paraphernalia and personal ornaments: five crowns, four headbands, at least 12 *tumi*-shaped head ornaments, at least six sets of gold feather head ornaments, three *tumbaga* fans and 14 large disks that were either ornaments for staffs or the backs of headdresses. At the bottom were the largest objects: four sets of parabolic headdresses that would have been set on top and in front of the crown.

Two of the seven niches carved into the walls of the burial chamber also contained metal objects. A pit dug into the largest niche, in the east wall, was packed with an estimated 1,500 bundles of *naipes*. These arsenical copper sheet objects of uniform shape and size may have served as currency. Each bundle consisted of 12 or 13 *naipes*. The pit also held two silver alloy *tumi* knives, thousands of small gold foil squares and at least two dozen *tumbaga* masks identical in shape to the large gold mask on the buried man but smaller, technically inferior and less ornamented. A second niche contained Gold Cache 2—another collection of gold ornaments and ritual objects. We also recovered from this grave more than 50 kilograms of diverse stone and shell beads, the carved wooden frame of a litter, about three kilograms of cinnabar and 21 ceramic vessels. Notable contents included clusters of 179 thorny oyster (*Spondylus princeps*) and 141 *Conus* (*C. fergusoni*) tropical seashells, probably imported from coastal Ecua-

THE AUTHORS

IZUMI SHIMADA and the late *JO ANN GRIFFIN* joined forces to investigate the precious metal artifacts of the Sicán. Shimada has conducted fieldwork on the north coast of Peru for the past 30 years and maintains interests in ancient technologies and the evolution of complex societies. A native of Japan, Shimada received his Ph.D. from the University of Arizona. He joined the department of anthropology at Southern Illinois University in 1994. Griffin had for almost 30 years been a goldsmith and conservator specializing in pre-Hispanic metallurgy, working with some of the largest public and private collections of pre-Hispanic gold in the world.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Sicán Metalworking Techniques

BASIC TECHNIQUES used by the Sicán goldsmiths are demonstated by Jo Ann Griffin, one of the authors.

1 **PRODUCTION** of Sicán sheet-metal objects began with an ingot of metal. Using the domed face of the hammerstone, the ancient goldsmith struck the ingot on a stone anvil.

2 **TO FLATTEN** the sheet, the metalworker used the flat face of the hammer. This process also removed dimples caused by the domed face.

3 **CUTTING** the sheet to shape was done with a *tumbaga* chisel.

4 **REPOUSSÉ** involves using another *tumbaga* tool to push up the gross form.

5 **CHASING:** The metalworker applies details to the front of the object by engraving or embossing.

dor. These shells are known to have held considerable symbolic value relating to the concepts of life force, water and fertility.

Our study differed from earlier ones in two important respects: we had access to materials from an intact tomb, and we had the benefit of the insights of metalworking specialists. Most published studies have focused on single aspects of the manufacture or use of pre-Hispanic precious metal artifacts. Such studies relied primarily if not exclusively on laboratory analyses of looted objects. Also, the investigators who have made inferences about the manufacturing techniques have rarely had personal knowledge of metalworking as a craft. The reconstructions emerging from those narrow, academic studies are therefore tenuous and biased. What this area of archaeology needs is more comprehensive studies of scientifically excavated samples from a multitude of analytical and interpretive perspectives. Only then will we gain an in-depth appreciation for the organization of metal production and the meaning of metal products within a culture—a "holistic vision" of metallurgy.

One of us (Griffin), a skilled metalsmith and longtime conservator, had experience with many pre-Hispanic collections. Because of her background, she was able to elucidate much about Sicán precious metal production by examining the Huaca Loro artifacts. Specialists in related fields helped us to interpret the evidence of other metal samples, feathers, beads and remains, including human skeletons, associated with the metal objects.

From its documented beginning around 1500 B.C.E., Andean metallurgy emphasized the use of sheet metal fashioned from ingots with stone anvils and hammers, in contrast to gold works in Central America and Colombia, where lost-wax casting was the main technique. Gold crowns and other ornaments found at various sites are all essentially gold sheets decorated with repoussé and cutout designs. In terms of the dimensions, smoothness, consistent thickness and overall quantity, the objects from the Huaca Loro tomb are prime examples of this sheet-metal tradition.

The primary tools for making sheet and wire are handheld stone hammers and companion anvils, chisels and chasing tools made of arsenical copper and *tumbaga*. The hammers are commonly of magnetite, hematite or fine-grained basalt; they range from very tiny to the size of a man's fist. One hammer face is usually domed for stretching the metal, and the other face is flat for planishing—removing the shallow dimples left by the stretching blows. When properly executed, this technique yields a flat, smooth sheet. Though simple to describe, the task requires considerable time and skill. Be-

JO ANN GRIFFIN

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

cause the sheet-metal maker must forge the gold while it is cold, the metal must be annealed regularly to prevent stress cracks.

Many gold objects in the Huaca Loro grave attest to remarkable expertise in sheet making. Consider, for example, the long borders on four parabolic head ornaments. Two of them are two-meter-long continuous strips of forged metal with an even width (around 4.5 centimeters) and thickness (about 0.15 millimeter)—virtuoso performances in sheet making. The mask (46 by 29 centimeters) that covers the face of the man buried in the tomb is another tour de force. It was fashioned from a sheet about 0.6 millimeter thick. The metal, composed of 52 percent gold, 31 percent silver and 17 percent copper (about 12.5 karats), had to be thin to keep down the mask's weight (only 677 grams) yet thick enough to allow the large naturalistic nose to be raised some four centimeters from the center without causing stress cracks. The high silver content, in addition to the gold of the alloy, provided the malleability necessary for the job. Silver-copper sheet metal was used for the whites of the eyes with a large pierced amber and emerald bead representing the iris and pupil of each eye, respectively. Our analysis indicates that the amber and emeralds were most likely imported from Colombia. Overall, the mask represents an elegant solution to the technical challenges as well as aesthetic and symbolic considerations of the Middle Sicán culture.

More than a dozen *tumi*-shaped headdresses provide additional illustrations of expert sheet-metal making. The tang, or stem, of each headdress had to be narrow but sufficiently stout (about a millimeter thick) to stay upright when inserted into a turban or crown socket. At the top the sheet is only about 0.15 to 0.18 millimeter thick. The smith knew just how much to planish the sheet to give it the right amount of springiness so it would wave with each movement of the head but not crack or bend.

The same is true for six sets of gold feathers that are believed to have been part of an elaborate headdress. The sets we have studied consist of 11 or 12 feathers, each about 20 to 21 centimeters long and two centimeters wide. Each feather tapers in thickness from the stem (about 0.10 millimeter) to the upper tip (about 0.07 millimeter). The sets as a whole have a fan shape: the central feather is straight, and those to the sides are increasingly more curved to the right or left. The component feathers are mechanically joined by straps and slots near their stems. Below the straps, each feather has a slight ridge along the longitudinal axis to provide some rigidity. Preserved on the stems are the imprints of fine threads that apparently stitched them to some cloth backing. The overall design and structure, as with the *tumi*-shaped headdresses, allowed the feathers to sway gently with head movements while staying rigid and light enough to mount securely on the headdress. In general, Middle Sicán precious metalworking emphasized movement as much as color (not only of gold but those of feathers, inlays and paints) and sound.

The six pairs of gold earspools found near the southeast corner of the tomb demonstrate a level of technical mastery rarely seen in pre-Hispanic gold objects. They display a constellation of design features that may well represent a single school of goldsmiths. The varied and advanced metalworking effects, not usually found together, include forged wire, true filigree, excellent finish and polish, and protobrazing. Protobrazing is a superbly simple

Many gold objects in the Huaca Loro grave attest to remarkable expertise in sheet making.

Closer Look

THROUGH ITS FLAWS, a gold beaker helps to reveal the methods of the Sicán craftsmen. The beaker (about 12 centimeters in height) is decorated with the chased representation of a Sicán lord, shown in its entirety in a modern drawing (*below*). The tool used for chasing was too wide and its edges too sharp to execute the lord's round chin, resulting in a ragged line. The silver base of the beaker shows an "orange peel" texture, the result of overheating. There are also traces of silver on the lower part of the gold beaker, suggesting that part of the silver base melted accidentally while it was being joined to the bottom of the beaker.

CÉSAR SAMILLÁN (*left*); YUTAKA YOSHII (*right*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

SMALL GOLD MASK (about seven centimeters in height) shows the exquisite chasing-repoussé details that are characteristic of these metalworkers. A close-up of the eyes and nose illuminates the oval indentations left by the tools.

method of joining gold or silver alloys that utilizes either the copper in those alloys or the verdigris (copper acetate) in an organic glue. The pieces to be joined are heated over charcoal in a reduction atmosphere; at the right temperature a new alloy forms where the metals touch.

To prevent the earspools from developing a torque while being inserted into the earlobes, the metalsmiths had made them from a relatively heavy gauge metal (about 0.35 to 0.55 millimeter thick). The front flange was domed by striking it from the back with a hammer against a shallow depression, probably in wood. The resultant domed flange greatly increased the twist strength while adding needed depth to the design of the piece.

In three of the pairs the metalsmiths implemented complex decorative designs by means of mechanical solutions that are simple and elegant. One such solution is the "tab and slot" joining of the sheet metal that forms the central rod connecting the front and back flanges. In several pairs the smiths also used wire structural supports to create the illusion that the central elements of the design "float" within the frame of the front flange.

One pair of the earspools, which might be called a "sketch" or trial piece, shows how the Sicán goldsmiths gradually refined the mechanical solutions to problems posed by an intricate new design. In this pair, very fine gold wire was used to anchor a circular frame to the X-brace below it. Other pairs, which were presumably made later, show the use of permanent protobraze joins for the same purpose.

An additional indication of careful planning comes from the gold mask, which has its own pair of large earspools anchored directly on the metal earlobes by straps and slots. Not only do the size and shape of the earlobes match those of the back flanges of the earspools, but the slots for all three straps on each ear also match. The slots were punched through both pieces simultaneously by the same vertical strokes. It is quite likely that the mask and all the earspools were manufactured according to high-quality standards in the same workshop.

Not all of the objects found in the Huaca Loro tomb are flawlessly finished. One example is the small double-bottomed beaker (about 12 centimeters high and 10 centimeters in diameter) found in the hand of a ceremonial gold glove. The base of the beaker is made of a raised silver sheet ornamented with cutout designs. It fit onto the base of the gold beaker and was intended to contain rattle stones. Part of the rim of the silver base is melted, and the base shows an "orange peel" texture, the result of overheating. The lower part of the gold beaker displays a distinctly gray semicircular coating that extends up the side, where a part of the silver base rim is missing. Those features suggest that part of the rim melted accidentally while the silver base was being joined to the bottom of the gold beaker. The cup was placed in the brazier upside down. It would not take more than a few seconds of overheating for the silver to melt and create the observed features. The base of the gold beaker was covered by a flash of melting silver as it flowed down toward the heat source. In general, the flawed pieces are most informative as to the manufacturing techniques and process.

Sicán culture must have employed a sizable corps of master sheet makers who produced sheet goods for various applications.

Sound Practice

OTHER TECHNICAL DETAILS on the beaker are also informative. For example, it is decorated with three chased representations of a Sicán lord. To create the image, the goldsmith used a tool called a tracer about three to four millimeters in width. That tool was too

YUTAKA YOSHII (*left*); JO ANN GRIFFIN (*right*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

wide and its edges too sharp for executing the round chin of the figure's face; as a result, the chin line is ragged. The metalworker made no attempt to correct the error when the chasing was finished on the outside of the beaker. This kind of mistake generally indicates haste or an apprentice worker.

The goldsmith would have stopped frequently to anneal the piece to prevent stress cracks from developing. How could he have known when to anneal? Immediately after annealing, the metal emits a dull sound when struck with a hammer. After repeated blows, the pitch of the sound becomes much higher, rising from a *thuk* sound to a *think*. With experience, one can tell from the pitch when it is time to anneal.

The impressive scale of sheet making during the Middle Sicán can best be seen in the 500 kilograms of scrap piled along the edges of the burial chamber at Huaca Loro. These piles are apparently not unique: local old-time looters recall finding similar quantities of scrap in other tombs nearby. In addition, we documented the extensive use of *tumbaga* sheets to line the interior of the gigantic Middle Sicán tomb at Huaca Las Ventanas. That tomb measured 15 by 15 meters at the mouth and three by three meters at the bottom, which was about 11 meters below the surface. Rectangular sheets of set dimensions were carefully placed side by side on the interior surface. They were then covered with cotton cloth that was painted with elaborate polychrome religious images and scenes. The total surface area of the sheets lining this tomb may have exceeded 100 square meters.

The scrap is essentially small pieces left over from sheet-metalworking processes and rejects from manufacturing mishaps. It includes, for example, a partially used *tumbaga* ingot, square gold foils with poorly executed perforations, broken wires and bells, and sheet-metal trimmings that still retain the outline of the cutout pieces. Such scrap would have been carefully saved for recycling into new ingots.

The scrap clearly represents an enormous investment of manpower and materials. Its presence in the tomb testifies to the political power of the person buried there. In one experiment, using ancient stone hammers, Griffin needed about a day and a half to produce a uniformly thin sheet 10 by 15 centimeters in size from a 30-gram gold nugget. Moreover, the ancient Sicán metalworkers added another step: they treated *tumbaga* sheets with acid, which dissolved some of the copper near the surface. As a result, the *tumbaga* sheets had an appearance that approximated that of 24-karat gold. This process is generally known as depletion gilding. The metalsmiths then burnished the sheets, which imparted an excellent finish and compacted the layer of spongy gold left by the depletion gilding. In our opinion, this compacted layer is the peeling gold often seen on gilded *tumbaga* pieces. Some researchers have proposed that this gilt was deposited electrochemically, but none of the examinations of the sheets conducted by us and others using microscopes and electron microprobes can find any evidence to support that idea.

Sicán culture must have employed a sizable corps of master sheet makers who produced sheet goods for various applications. The remarkable degree of control over forging and finishing seen in these objects argues persuasively that those activities were in the hands of full-time specialists. These master sheet makers would have been assisted by perhaps dozens of apprentices who would have carried out repetitive and time-consuming tasks, such as burnishing or

RECONSTRUCTION of the principal person in the Huaca Loro tomb shows him in his regalia. It is based on a gold cut-out figure, found inside his tomb, that is thought to represent him. He holds a ceremonial staff in his left hand, a dart thrower and darts in his right. These and the items he wears were all found on or close to him within the tomb.

PREPARED BY LUIS TOKUDA AND IZUMI SHIMADA

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

the early stages of remelting scraps to prepare ingots for making sheets.

This master-apprentice arrangement is clearly visible in the manufacturing stages of other objects. One crown in particular shows well-done chasing and perforations in the front but uneven hammer blows and perforations, as well as fine-scribed guidelines on the back. It is likely that the front was begun by a master who showed an apprentice how the remainder was to be done and then went on to another task.

This type of workshop would probably have required a series of multiroom shops, each with a fair number of apprentices and a sizable output. Sheet making, which entails long hours of rhythmic hammering periodically interrupted by annealing, most likely took place in a well-ventilated room. Polishing was probably done in a separate, well-protected room, because airborne sand and other contaminants would have wreaked havoc with the polishing efforts. Significantly, multiroom adobe structures atop the north platform of Huaca Loro and northeast of Huaca Las Ventanas have benches, split-level floors, and many dispersed spots where one can find slag fragments, droplets of copper alloys and evidence that fire was used there. Those two areas were probably centers of metalworking.

Making metal sheet requires great finesse. The shaping and ornamentation of gold objects would have been in the hands of even more consummate master specialists. Because of their exceptional quality, innovative designs and technical distinctiveness, the mask and earspools in the Huaca Loro tomb are probably the products of only one or two masters. Other gold objects, we suspect, were manufactured in other workshops. Although those workshops may have performed different functions, it is unlikely that they were isolated: part of the apprenticeship training would have depended on frequent association with the masters. The apprentices were no doubt given tasks, such as making bangles, that were instructive but did not pose too many technical challenges.

Some of the observed technical variation may reflect the goldsmiths' personal styles. Many of the gold objects from Huaca Loro are nearly identical in size and shape but were clearly made in different ways. For example, on some rattles, bangles were attached to the "floating" circular bands by protobrazed wires, whereas others were attached by wire loops. Some of the sharp gold nails used on a dart thrower were cut in a sawtooth pattern from hand-forged wire with a chisel; others were cut from the end of wire that had been filed to a conical shape.

Such observations lead us to conclude that the production of metal objects was organized into task-specific work groups, which in turn were based on a nested hierarchy of masters, apprentices and other supportive personnel. Precious metalworking must not be viewed in isolation from other crafts. Considerable effort had to go into the procurement and preparation of feathers, cinnabar, hematite and other materials that covered the metal objects. Turquoise, shells, bitumen and other substances were needed for inlays. Resins and pitch had to be prepared to make adhesives. Cloth had to be woven as a backing material. We know that

Making an Earspool

EARSPOOLS represent some of the most technologically sophisticated metalwork of the Middle Sicán. A back view (*bottom left*) shows construction details, including an X-shaped brace attached by protobrazing. A side view (*bottom right*) details another method of joining, the slot-and-tab construction. Spools are about 10 centimeters in diameter.

YUTAKA YOSHII (*top*); IZUMI SHIMADA (*bottom*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

CUTOUT FIGURES (about 12 centimeters in height) once decorated the upper right sleeve of the dress worn by one of the two sacrificed women.

arsenical copper was produced on a large scale at specialized settlements close to the mines. All these activities need to be considered to appreciate the impressive magnitude and complexity of the production of sumptuary goods during the Middle Sicán.

Meaning of Metalwork

FOR THE SICÁN PEOPLE to have invested so much effort in metalworking, metal objects must have held strong meaning for them. We have developed some working hypotheses about what that meaning was. Gold objects seem to have been the aesthetic locus of Middle Sicán art—they embodied the highest standards for artistic expression in the culture. And it is among the gold objects that we find the most explicit expressions of the important Middle Sicán icons and scenes. Ceramic decorations, in comparison, present only partial or simplified versions of these portrayals.

Differential access to a range of metals seems to have marked the social strata. Approximately five dozen excavated burials can be grouped into those that contain no metal objects, those that contain only arsenical copper, those that have arsenical copper and *tumbaga* items, and those that have gold in addition to those other materials. *Tumbaga,* along with gold and silver, seems to have been used to symbolize political power or high social status and to convey religious messages. In terms of the scale of production and the range of use, *tumbaga* appears to top the list of precious metals. Yet it was secondary to gold in the perception of the Middle Sicán elite. The personal ornaments immediately surrounding the central body at Huaca Loro were all gold. The *tumbaga* objects were placed at the periphery of the burial chamber, and their use was probably auxiliary.

In other words, the gold objects were reserved for the personal use (including ornamentation and ritual paraphernalia) of the highest elite, whereas gilded *tumbaga* was used to decorate items associated with them as well as the objects used by lower-echelon elites. *Tumbaga* allowed those lower in status to emulate their social superiors. Gilded *tumbaga* with relatively low gold content would have been a most practical substitute for meeting the broad demand for rich gold-colored sheet metal.

Many of the precious metal objects found in the tomb were probably used together in public settings for ostentatious displays to impress onlookers. The full ceremonial regalia of the important person buried in the Huaca Loro tomb offers a vivid example.

Depending on the ritual to be conducted, he would have worn various headdresses—sometimes a crown decorated with sets of gold feathers or *tumi*-shaped ornaments, sometimes a large parabolic headdress in addition to the crown. The upper perimeter and draping sides of that parabolic headdress would have been decorated with colorful bird feathers and bangles that reached almost to the shoulders. Over his face he would have worn a gold mask. He was probably carried on a wooden litter decorated with the carved heads of mythical animals. The litter was likely to have been flanked by people waving long *tumbaga* fans and preceded by someone holding a staff or standard almost two meters high, which was bright and colorful with gold and feathers. With each step, each breath of air, the bangles, gold feathers and other delicately articulated metal objects would have been set in motion to create a dazzling visual and auditory effect. It is not hard to be entranced by the thought of that luminous figure—or by thoughts of what future studies of Sicán artifacts may yet tell us about that lost culture. SA

MORE TO EXPLORE

Copper-Alloy Metallurgy in Ancient Peru. Izumi Shimada and John F. Merkel in *Scientific American,* Vol. 265, No. 1, pages 80–86; July 1991.

A Sicán Tomb in Peru. Izumi Shimada and John F. Merkel in *Minerva,* Vol. 4, No. 1, pages 18–25; January/February 1993.

Technology, Iconography, and Social Significance of Metals: A Multi-Dimensional Analysis of Middle Sicán Objects. Izumi Shimada, Jo Ann Griffin and Adon Gordus in *Precolumbian Gold: Technology, Style and Iconography.* Edited by Colin McEwan. British Museum Press, 2000.

An Integrated Analysis of Pre-Hispanic Mortuary Practices: A Middle Sicán Case Study. Izumi Shimada, Ken-ichi Shinoda, Julie Farnum, Robert Corruccini and Hirokatsu Watanabe in *Current Anthropology,* Vol. 45, No. 3; pages 369–402; 2004.

YUTAKA YOSHII

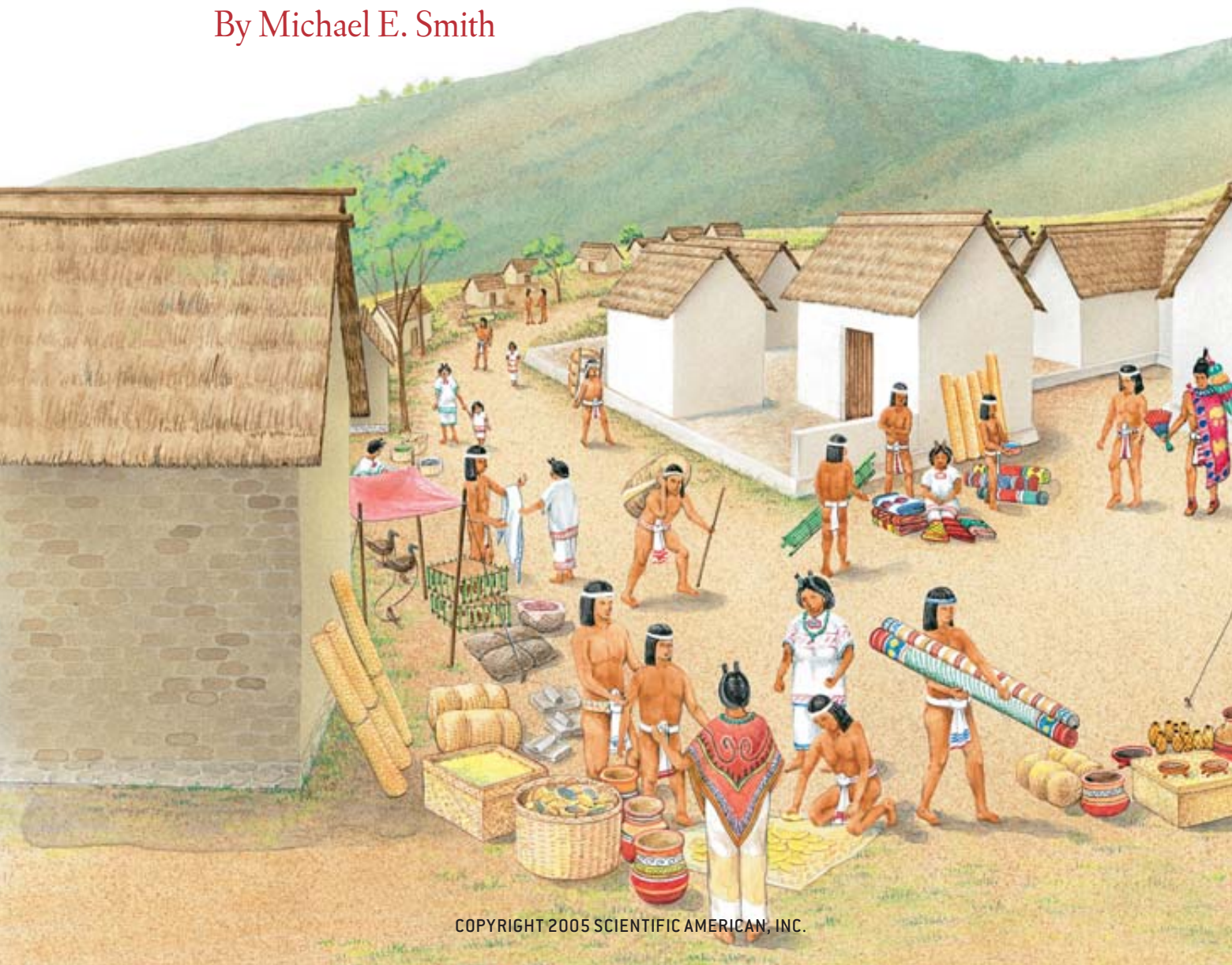
COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Mexico

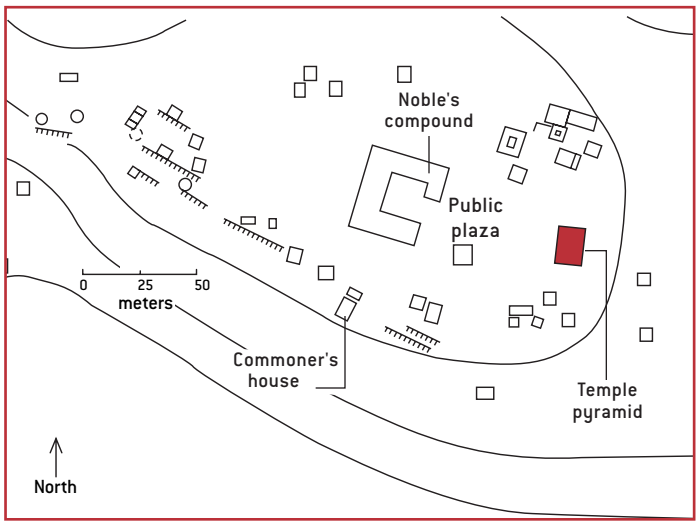
LIFE IN THE PROVINCES OF THE AZTEC EMPIRE

The lives of the Aztec common people were far richer and more complex than the official histories would have us believe

By Michael E. Smith



COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.



MARKET PLAZA in the 15th-century Aztec town of Cuexcomate teemed with vendors, buyers and artisans. Here commoners could trade craft goods made in their homes—mainly textiles—for salt and painted pottery imported from the Valley of Mexico and other areas, obsidian blades from regions hundreds of kilometers away, and needles and other bronze objects from western Mexico. Local produce and goods such as woven mats, baskets, corn-grinding tools and tortilla griddles were also displayed and traded. A map of the center of the modern dig site at Cuexcomate (*left*) indicates the location of the temple pyramid, a noble family's compound and commoners' dwellings. The reconstruction below depicts these as well as other buildings and more distant terraced fields and rural dwellings.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

In 1519, when Hernán Cortés led his army into Tenochtitlán in the Valley of Mexico, that Aztec city was the capital of a far-flung tributary empire. The emperor Motecuhzoma sat atop a complex social and political hierarchy, and the Aztec populace owed allegiance and tribute to nobles at several levels. Below the emperor were the kings of subject city-states. The Aztec dominion employed a policy of indirect rule, and imperial authorities supported local dynasties so long as they delivered their quarterly tribute payments on time. Officials recorded these payments in documents such as the Codex Mendoza [see "The Codex Mendoza," by Patricia Rieff Anawalt and Frances F. Berdan; SCIENTIFIC AMERICAN, June 1992]. Local nobles, who lived in both urban and rural areas, were subjects of their city-state king. At the bottom of the hierarchy were the commoners, whose tribute payments supported all these nobles.

Aztec commoners must have had a heavy tribute obligation. How were they able to meet their payments? First of all, there were millions of commoners, so the tribute burden was spread over a large population. During the 1970s, surveys of patterns of settlement turned up the startling discovery that the Aztec period witnessed one of the major population explosions of antiquity. The number of people in the Valley of Mexico, the heartland of the Aztec Empire, increased from 175,000 in the early Aztec period (1150–1350 C.E.) to nearly one million in the late Aztec period (1350–1519 C.E.). Similar patterns of growth occurred in other parts of Aztec territory as well.

The Aztec population explosion placed a heavy stress on the environment of central Mexico. New villages and towns sprung up everywhere, and all available land was cultivated, often at considerable labor expense. Wherever possible, farmers built dams and canals to irrigate cropland; they also built terraced stone walls on hillsides to make new fields; and they drained the swamps outside Tenochtitlán to create raised fields (*chinampas*), one of the most highly productive agricultural systems of the ancient world. These intensive farming practices transformed the central Mexican countryside into a managed landscape of cultivation.

What were the effects of tribute extraction, population growth and agricultural intensification on the Aztec common people? Did these processes leave people impoverished and powerless, or did they allow commoners to prosper and thrive? Few of the available written accounts have information on conditions beyond the imperial capital, and thus it is up to archaeologists to study these questions.

Until recently, no major archaeological excavations had been carried out at Aztec sites. Most Aztec cities and towns either were destroyed during the Spanish Conquest or were occupied and then buried under later settlements. The few surviving sites were small, unassuming peasant villages. Most archaeologists working in Mesoamerica bypassed Aztec sites on their way to the spectacular jungle ruins of Classic-period Maya civilization. Aztec sites were deemed either too difficult to excavate or too small to bother with. This neglect came to an abrupt end in 1978, when the Mexican government mounted an extensive excavation of the Great Temple of Tenochtitlán. Situated in the middle of Mexico City today, this magnificent structure, and the richness of the offerings associated with it, awakened a new interest in Aztec society. Unfortunately, these excavations did not provide much new information about the commoners or life in the provinces.

To address these issues, my wife, Cynthia Heath-Smith, and I embarked on archaeological projects at rural and urban sites in the modern Mexican state of Morelos. Located just south of the Valley of Mexico, this was the first area outside the valley to be conquered when the Aztecs began their military expansion in the 1430s.

We first excavated two rural sites—Capilco and Cuexcomate—southwest of the modern city of Cuernavaca. Later we turned to the Aztec city of Yautepec in north-central Morelos. By excavating the houses of both rich and poor, we have found that provincial society was far more complex than previously thought. Aztec peasants were not simple farmers whose lives were dominated by the need to pay tribute to their elite overlords. Commoners living in both rural and urban areas of the provinces made heavy use of a thriving marketing system. They exchanged craft goods produced in their homes for a variety of foreign goods, and most of this eco-

THE AUTHOR

MICHAEL E. SMITH is a professor in the department of anthropology at the University at Albany, New York. Born in the Philippine Islands, he received his undergraduate degree from Brandeis University and, in 1983, his doctorate in anthropology from the University of Illinois. Before joining the faculty at the University at Albany, Smith taught at Loyola University in Chicago. His research focuses on the archaeology and ethnohistory of postclassic central Mexico. The excavations described in this article were funded principally by the National Science Foundation and the National Endowment for the Humanities.

preceding pages: MICHAEL E. SMITH (*map*); TOMO NARASHIMA

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

TYPICAL PEASANT HOUSE was small (roughly 15 to 25 square meters) and probably had two doors and no windows. Many activities, such as the ubiquitous weaving, took place in patios between the dwellings. Houses were furnished with mats and baskets; a simple shrine with two or three figurines and an incense burner adorned one wall. The absence of hearths is puzzling; quite possibly cooking was done, as it is in traditional villages today, in a lean-to against the back of the house.

nomic activity was accomplished outside imperial control and ignored by early writers on the Aztecs.

Peasant Life

ARCHAEOLOGISTS have found that excavations of houses and associated remains often provide the best data on ancient social and economic patterns. Capilco and Cuexcomate were good examples because traces of house walls were visible above the ground, and we did not have to waste time trying to find buried structures. Capilco was a village with 21 houses, and Cuexcomate a town with more than 150 structures, including temples, storehouses and ritual dumps. Houses at these sites were small (with a mean area of 15 square meters) and built of adobe brick walls supported on stone foundations. We excavated test pits in 29 houses selected at random. We then chose 10 of these for more complete clearing of architecture and associated deposits. These excavations allowed us to refine the Aztec chronology by splitting the late Aztec period into two subperiods—late Aztec A (1350–1440) and late Aztec B (1440–1519)—to yield a more detailed analysis.

Capilco was founded by a few peasant families in the early Aztec period. The population explosion began in the late Aztec A period, when Cuexcomate was founded and both settlements grew rapidly. The residents of these communities could not support themselves using rainfall agriculture alone, so they had to intensify their agricultural practices. Farmers built terraces on slopes and in ravines to create additional, more productive plots in which they grew maize, beans and cotton. Houses at these sites were not packed very closely together, and open areas were probably devoted to farming.

Cotton was an important crop in this part of the Aztec Empire, and household production of cotton textiles soon became the major craft. Every excavated house yielded large quantities of ceramic artifacts used in the hand spinning of cotton. Beadlike spindle whorls provided weights for the twirl-

TOMO NARASHIMA

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

ing wooden spindle, and small bowls with tripod supports were designed to control the spindle. Documentary sources state that all Aztec women, from the lowest slave to the highest noblewoman, spun and wove cloth. Cotton textiles had two economic functions beyond use as clothing. First, they were the most common item of tribute demanded by both city-states and the Aztec Empire. Second, they served as a form of money in the marketplaces, where they could be used to obtain a range of goods and services.

In addition to textiles, some residents of these sites manufactured paper out of the bark of the wild fig tree, as attested to by "bark beaters" made of basalt. The Aztecs used paper to make books of picture-writing and to burn in ritual offerings.

The many ceramic vessels used and discarded at each house were probably purchased in the marketplaces. Although local potters produced a full range of vessels, people often bought many decorated foreign pots. About 10 percent of all ceramic vessels excavated from these sites had been imported from the Valley of Mexico and other areas. These vessels did not have any functional superiority to the wares made locally, and people must have simply enjoyed using a variety of decorated serving bowls.

In addition to ceramic vessels, people had other foreign goods in their homes. We recovered thousands of broken obsidian blades, whose closest geological source was 100 kilometers away. Obsidian blades, which had extremely sharp cutting edges, served in many household and craft activities. Needles and other items of bronze were imported from western Mexico. People obtained salt from the Valley of Mexico, where specialists extracted it by boiling and evaporating the saline lake water. Salt was transported in distinctive ceramic basins, and in every excavated house we found many shards of these vessels. The market system connected the inhabitants of these rural sites to the rest of the Aztec Empire and beyond.

These excavations also revealed something of the noneconomic life of Aztec peasants. For example, every house contained a variety of incense burners and small ceramic figurines in the forms of humans and deities. These artifacts played a role in domestic rituals, which focused on purification and curing. Such ceremonies complemented the more spectacular public celebrations that took place at the towering temple pyramids in the larger cities and towns. Early Spanish priests described in detail the Aztec public religion, and excavation of the Great Temple has shown where these activities occurred. Before the recent excavations of houses, however, scholars had no idea of the nature of domestic rituals.

Not surprisingly, the larger town of Cuexcomate was a more complex community than Capilco. The town was laid out around a public plaza with a small temple pyramid on its east side. Across

AZTEC EMPIRE covered much of central and southern Mexico when Spanish conquerors arrived in 1519. The sites described in the article were part of the tributary provinces of Cuauhnahuac and Huaxtepec, located in what is now the Mexican state of Morelos. Four times a year the people of these provinces delivered large amounts of tribute in cotton textiles and other products to the imperial capital, Tenochtitlán.

JOHNNY JOHNSON

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

the plaza from the temple was a distinctive residential compound that, at 540 square meters, was significantly larger than the other houses. Its rooms were elevated above ground level by stone platforms. The compound employed finer construction materials and methods than most houses, including ample use of lime plaster. These features, combined with a floor plan that corresponds to the layout of Aztec palaces, led us to conclude that the compound was the residence of a noble household.

The artifacts left by the nobles who lived in this compound differed in quantity but not in kind from the artifacts found in the dwellings of commoners. For example, this structure yielded significantly greater numbers of imported and decorated ceramics than did the commoners' houses, as one might expect. Nevertheless, nobles did not have exclusive use of any category of artifact. We uncovered the most costly imported goods, such as polychrome bowls from the religious center of Cholula, bronze objects and jade jewelry, at both common and noble residences, showing that both groups had ready access to the extensive Aztec marketing system of central Mexico.

The conquest of this region by the Aztec Empire around 1440 ushered in the late Aztec B period. Soon after, the noble's compound at Cuexcomate was abandoned, and a new, smaller elite compound was built on the north side of the plaza. Populations continued to grow; Cuexcomate expanded from 200 to 800 persons, and Capilco grew from 35 to 135 persons in the late Aztec B period. Agricultural workers constructed extensive terracing to keep up with population growth, but farming reached a point of diminishing returns as all available land was terraced.

Artifacts and architecture provide clues to ancient standards of living, and evidence at these sites points to a significant decline between periods A and B. For example, nobles as well as commoners had fewer imported goods and fewer decorated ceramic vessels in the later period. Wealth indices, which we calculated from the quantities of valuable artifacts found at each house, showed a consistent decline. Some commoners tried to compensate for their economic difficulties by increasing their production of textiles. At each site, the houses with the most cotton spinning artifacts were the ones with the lowest wealth indices. In other words, the poorest households put the greatest efforts into craft production, probably to compensate for low crop yields or a lack of land. This pattern has occurred in many parts of the world when overpopulation and land scarcity have led to a declining standard of living.

Figurine molds

House foundation

Ceramic tools for spinning cotton

Fragments of imported pottery

Bronze implements

Ritual figurines

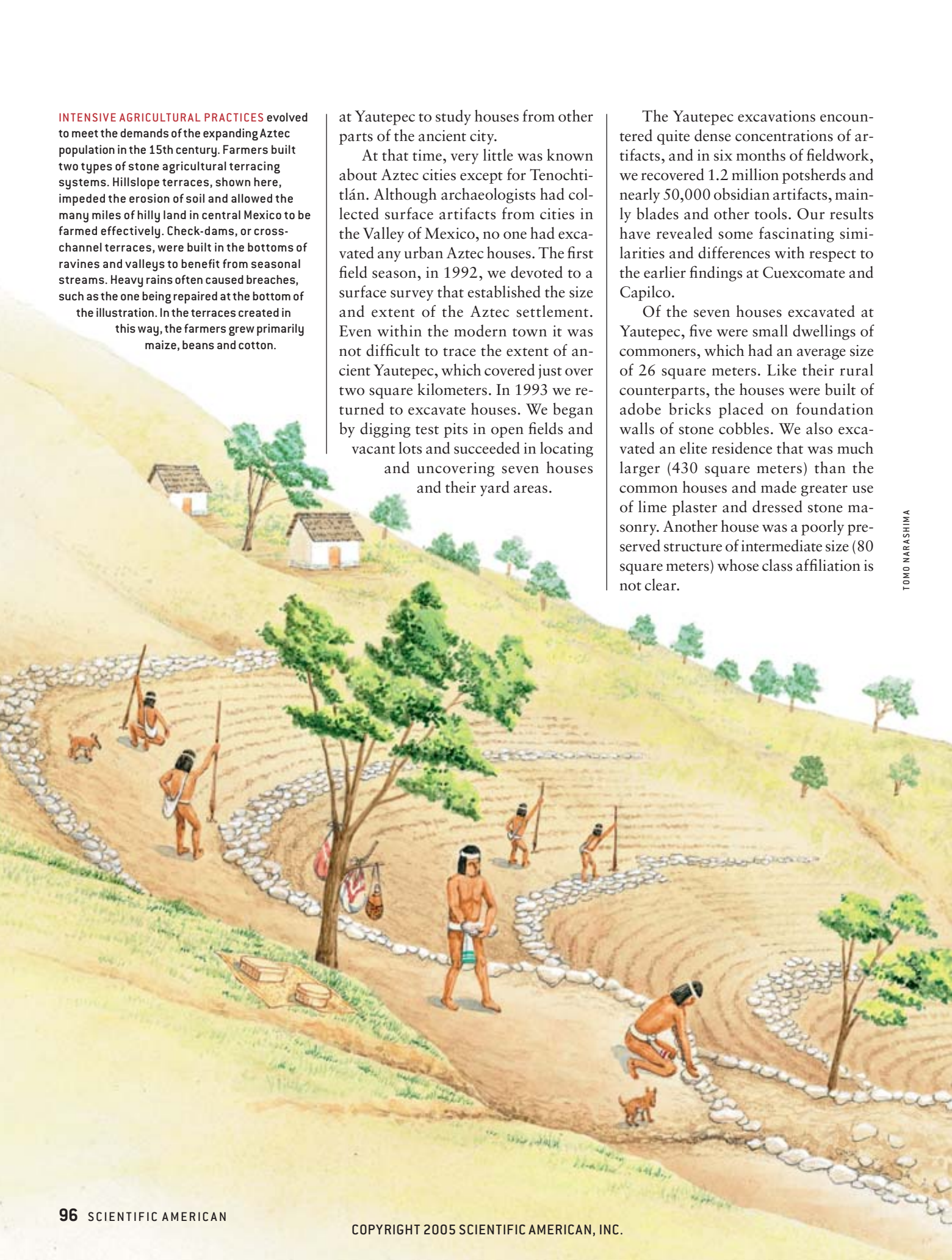
ARTIFACTS unearthed in the modern Mexican state of Morelos from trash middens adjacent to Aztec dwellings of the 12th through 16th centuries were used for domesic rituals, weaving and other tasks.

Urban Life

TO ROUND OUT our study of provincial life, we turned to Yautepec, the capital of a powerful city-state in Aztec times. Former Aztec cities in central Mexico are still occupied today, with the ancient ruins buried under layers of historical and more modern settlement. The early Spaniards built Christian churches on top of the remains of Aztec pyramids and placed their own towns over the Aztec cities. In this respect, Yautepec is unusual. There the Spanish settlement covered only part of the city. In 1989 Hortensia de Vega led a team of archaeologists from Mexico's National Anthropology Institute in the excavation of a large mound at the edge of modern Yautepec. This mound turned out to be the ruin of the royal palace of Yautepec. It is one of the few Aztec palaces to be extensively excavated. We were invited to join the work

PHOTOGRAPHY BY MICHAEL E. SMITH

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.



INTENSIVE AGRICULTURAL PRACTICES evolved to meet the demands of the expanding Aztec population in the 15th century. Farmers built two types of stone agricultural terracing systems. Hillslope terraces, shown here, impeded the erosion of soil and allowed the many miles of hilly land in central Mexico to be farmed effectively. Check-dams, or cross-channel terraces, were built in the bottoms of ravines and valleys to benefit from seasonal streams. Heavy rains often caused breaches, such as the one being repaired at the bottom of the illustration. In the terraces created in this way, the farmers grew primarily maize, beans and cotton.

TOMO NARASHIMA

at Yautepec to study houses from other parts of the ancient city.

At that time, very little was known about Aztec cities except for Tenochtitlán. Although archaeologists had collected surface artifacts from cities in the Valley of Mexico, no one had excavated any urban Aztec houses. The first field season, in 1992, we devoted to a surface survey that established the size and extent of the Aztec settlement. Even within the modern town it was not difficult to trace the extent of ancient Yautepec, which covered just over two square kilometers. In 1993 we returned to excavate houses. We began by digging test pits in open fields and vacant lots and succeeded in locating and uncovering seven houses and their yard areas.

The Yautepec excavations encountered quite dense concentrations of artifacts, and in six months of fieldwork, we recovered 1.2 million potsherds and nearly 50,000 obsidian artifacts, mainly blades and other tools. Our results have revealed some fascinating similarities and differences with respect to the earlier findings at Cuexcomate and Capilco.

Of the seven houses excavated at Yautepec, five were small dwellings of commoners, which had an average size of 26 square meters. Like their rural counterparts, the houses were built of adobe bricks placed on foundation walls of stone cobbles. We also excavated an elite residence that was much larger (430 square meters) than the common houses and made greater use of lime plaster and dressed stone masonry. Another house was a poorly preserved structure of intermediate size (80 square meters) whose class affiliation is not clear.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Yautepec commoners, like their country cousins at Capilco and Cuexcomate, had ready access to foreign goods. The same kinds of imported ceramics, obsidian, salt, jade and bronze were found in residences at Yautepec. Chemical evaluation using instrumental neutron-activation analysis (at the University of Missouri Research Reactor Center) confirmed our initial interpretations of the local and imported origins of various types of ceramics. We learned that vessels of the well-known type "Aztec III black-on-orange" were imported from at least four different workshop areas in the Valley of Mexico. Ninety percent of the obsidian artifacts have a distinctive green tint that identifies their place of origin as the Pachuca geological source area, north of the Valley of Mexico. The remaining 10 percent of obsidian tools—as determined by x-ray fluorescence studies at the University at Albany—came from at least 10 other geological sources scattered throughout central Mexico. For whatever reason, the people who lived in the houses excavated at Yautepec all used obsidian tools from five different geological sources.

One set of analyses we have completed illuminates the origins of the bronze artifacts. Dorothy Hosler of the Massachusetts Institute of Technology analyzed the chemical composition, design and metallurgical properties of metal artifacts from all three of the sites. These objects include sewing needles, awls, bells and tweezers, all composed of copper-tin- or copper-arsenic-bronze alloys. Morelos was not a metal-producing zone in ancient times, and these artifacts closely resemble the bronze artifacts made in the Tarascan Empire of western Mexico.

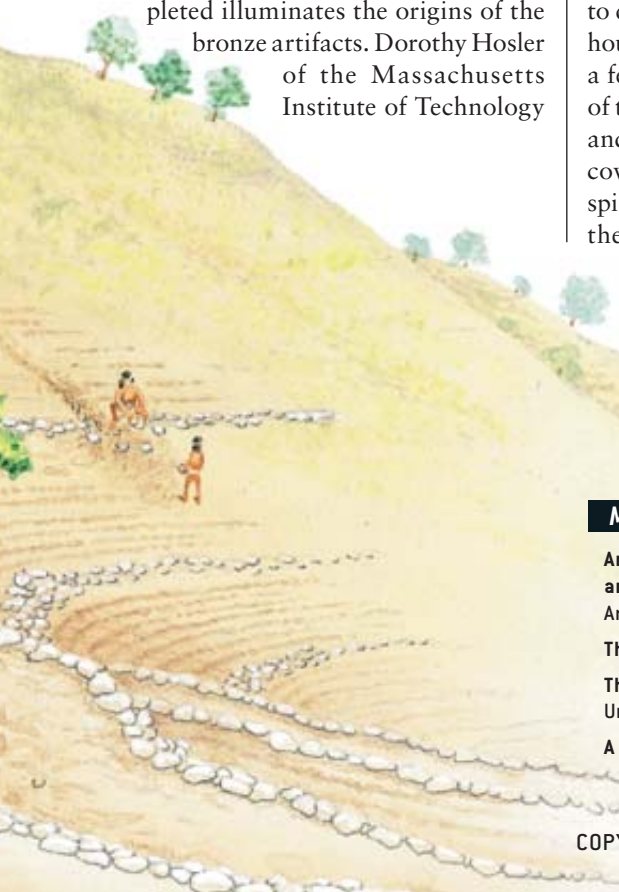
Hosler has completed the first application of lead isotope analysis to ancient Mesoamerican metallurgy by sampling ore sources in several areas and artifacts from a variety of sites, including Yautepec. A number of the Yautepec bronze objects match ore samples from the Tarascan territory. Although written sources report that the Aztecs and Tarascans were constantly at war, the excavations nonetheless provide clear evidence that Tarascan bronze and obsidian were traded across the border and that they made their way into the homes of provincial commoners through the Aztec marketing system.

Crafts and Cotton

YAUTEPEC, unlike the rural sites, had numerous craft industries in addition to domestic textile production. Several households made obsidian blades, and a few excavations uncovered evidence of the production of lip plugs, earplugs and other obsidian jewelry. We also recovered molds used to make ceramic spindle whorls and figurines. Although these molds are not abundant, they were found in many different excavations at Yautepec. Bark beaters for the manufacture of paper were also present. At this point, it appears that many of the common households at Yautepec produced various craft items in addition to cotton textiles.

What do these excavations tell us about the people who lived in the provinces of the Aztec Empire? The overall impression is that provincial commoners were relatively prosperous, enterprising people. In spite of an economic decline after conquest and incorporation into the Aztec Empire, commoners in both urban and rural settings still enjoyed access to a wide range of imported goods. These goods were obtained through the markets. Both documentary and archaeological data indicate that the Aztec market system operated largely outside state control. The markets connected people in even the smallest peasant villages with the larger informal Aztec economy of central Mexico. Family members engaged in a variety of craft activities to produce goods to sell in the markets. At sites in Morelos, the most important of these products were cotton textiles manufactured by women in their homes.

Written sources tell us that Aztec commoners were subject to nobles, who owned most of the land and monopolized power within the city-states. Archaeological excavations suggest that at least in several provincial settlements, this burden was not excessive. There is no evidence to suggest that nobles controlled craft production or exchange. The people in the provinces managed to achieve a degree of economic success through channels unconnected to the state and unreported in the official histories of the Aztecs. Illuminating the lives of these previously invisible people is one of the rewards of being an archaeologist today. SA



MORE TO EXPLORE

Archaeological Research at Aztec-Period Rural Sites in Morelos, Mexico, Vol. 1: **Excavations and Architecture.** Michael E. Smith. University of Pittsburgh Memoirs in Latin American Archaeology, No. 4, 1992.

The Aztecs. Second edition. Michael E. Smith. Blackwell Publishers, 2003.

The Postclassic Mesoamerican World. Edited by Michael E. Smith and Frances F. Berdan. University of Utah Press, 2003.

A Quarter-Century of Aztec Studies. Michael E. Smith in *Mexicon,* Vol. 25, pages 4–10; 2003.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Reading the Bones of La Florida

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

New approaches offer insight into the lives of

Native Americans after the Europeans arrived

By Clark Spencer Larsen

The lives of Native Americans changed in dramatic ways after Christopher Columbus landed in the Caribbean in 1492. Written records paint a vivid picture of conquest and epidemics sowing death and disease among the indigenous peoples of the Americas, quickly decimating them. Until recently, in fact, almost all that was known about the biological consequences of contact with the Europeans was based on these old documents, which emphasize epidemics and population collapse. These texts offer an important perspective, but they are not the only source of information.

Bioarchaeology, an emerging field that focuses on the study of archaeological remains, is supplementing our view of the health and daily life of Native Americans, particularly those who lived in the Spanish missions of the Southeast, in an area once known as *La Florida*. Sustained encounters between Indians and Europeans in *La Florida* began in 1565, when Pedro Menéndez de Avilés established the town of St. Augustine on the Atlantic coast in northern Florida. From there Roman Catholic priests set up a chain of missions among the Timucua and Apalachee Indians of northern Florida and the Guale Indians of the Georgia coast. At some of those places—including Santa Catalina de Guale on St. Catherines Island, San Martín de Timucua and San Luis de Apalachee—archaeologists have uncovered the ruins of large churches that served the converts. As the nucleus of each community, the church carried out important religious functions for the living; for the dead, it provided a burial ground.

Skeletons found beneath the floor of these churches have a surprisingly complete record of the diet and work habits of the mission Indians. Bioarchaeology is beginning to fill in the details of the historical record, offering specifics about how food sources changed and raising unexpected questions about the merits of a purely agricultural way of life—at least for the Indians who inhabited *La Florida*.

Before our research, the diets of *La Florida* Indians were reconstructed from two sources: accounts by priests and other Europeans, and food remains at archaeological sites. The written records are often contradictory. Some depict little farming at the time. Others say that indigenous peoples relied heavily on agriculture, particularly on corn.

The archaeological record is inconclusive as well. Plant remains do not always survive well, and in coastal regions they are particularly vulnerable to the destructive effects of moisture and acidic soils. Nevertheless, analysis of such evidence has revealed that native peoples ate numerous plant species, both wild and domesticated, before and after the arrival of the Europeans. But their use of corn is unclear. Excavations have revealed some kernels and cobs from late prehistoric and contact-era sites; however, the relative importance of this grain in the Indians' diet is not known.

ORIGINAL OIL PAINTING BY EDWARD JONAS, *THE MISSION CHURCH AT SAN LUIS DE TALIMALI, 1656–1704*; COURTESY OF MISSION SAN LUIS, FLORIDA DIVISION OF HISTORICAL RESOURCES; ROBERTO OSTI (*map*)

SPANISH MISSIONS, such as this one at San Luis de Apalachee (*left*), were established throughout what is now Florida and coastal Georgia. Serving three primary tribes—the Guale, the Apalachee and the Timucua—these missions became centers of social and religious life.

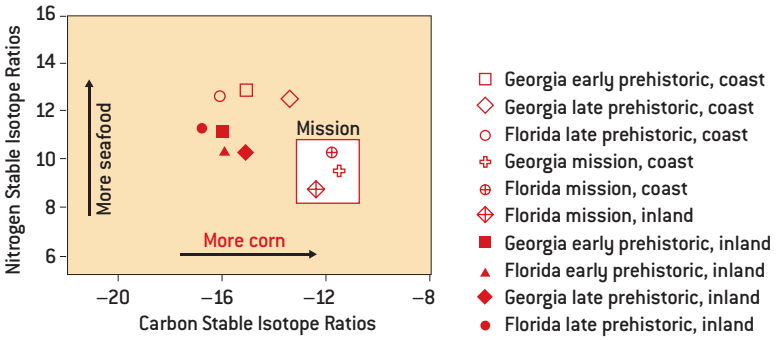
COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

Reconstructing Diet

TO RESOLVE some of these questions, we turned to the many bones found at these sites. Because the tissues of all living things contain stable isotopes of such elements as carbon and nitrogen, we can measure the amounts of these elements in bones and then use this information to reconstruct ancient diets. Differences in the ratios of two carbon isotopes, carbon 12 and carbon 13, contain a record of which plants an individual ate. Most plants are divided into two types: carbon 3 plants break down a three-carbon molecule during photosynthesis; carbon 4 plants synthesize a four-carbon molecule. The distinctive chemical signature of the C_3 and C_4 plants that a person consumes shows up in his or her bones. Virtually all plants eaten in the *La Florida* region were of the C_3 variety—including fruits, wheat, acorns and hickory nuts. The only major C_4 plant eaten by native peoples was corn.

Nitrogen isotopes provide a different set of clues. Fish bones and oyster shells in archaeological sites indicate that the Guale and other native peoples of the region ate seafood regularly—before and after the Europeans arrived. Because marine plants, such as algae, and terrestrial plants use the two stable isotopes of nitrogen—nitrogen 14 and nitrogen 15—differently, the ratios of these isotopes are distinct in the bones of a person who ate mostly marine foods as opposed to one who ate mostly terrestrial foods.

Examining the differences between carbon and nitrogen ratios in bones before and after the Europeans arrived pointed to enormous changes in the Native Americans' diets. My colleagues and I found that the variations were geographically and chronologically patterned. As would be expected, coastal people ate more seafood than inland people did, regardless of the era. The Guale Indians on St. Catherines and Amelia islands ate corn before and after the missionaries arrived. But during the mission period, they ate more than their ancestors had. Similarly, the Apalachee, who had eaten some corn before contact, seemed to eat it more after the Europeans arrived; and the Timucua, who had eaten little or no corn before contact, also adopted it after the establishment of the missions.



RATIOS OF ELEMENTS, such as carbon and nitrogen isotopes, provide important information about diet. Recorded in bones, these varying ratios reveal what kinds of plants or how much seafood an individual ate.

Consequences of Corn

THE BONE CHEMISTRY findings thus show that the Indians' diets changed after the Europeans came—but not for the better. Their relatively heterogeneous diet, rich in seafood and a variety of plants and animals, was replaced by a more homogeneous and less nutritious diet focused on the cultivation of a single crop: corn.

Corn-dominated diets are very poor ones. Corn contains a great deal of sugar, which promotes cavities and poor oral health in general. It also contains phytate, a chemical that binds with iron, inhibiting absorption of the mineral by the body. As a result, people whose diets are heavy in corn are predisposed to anemia and the many other consequences of low iron [see "Iron Deficiency," by Nevin S. Scrimshaw; SCIENTIFIC AMERICAN, October 1991]. To make matters worse for corn-dependent populations, growth and development are hampered because corn is a poor source of calcium and of niacin, or vitamin B_3, which is necessary for metabolism. Corn is also an inadequate source of protein because, depending on the strain, it is deficient in or entirely lacking three of the eight essential amino acids: lysine, isoleucine and tryptophan.

For these reasons, some mission Indians have more, and larger, cavities than their ancestors did. Tooth decay was probably exacerbated by the consistency of their food: soft foods, such as gruel made from corn, facilitate the buildup of cavity-causing bacteria and plaque on teeth. By looking at tooth wear with a scanning electron microscope, Mark F. Teaford and his colleagues at Johns Hopkins University have shown that the foods eaten by mission Indians were softer than those their ancestors ate.

In places where diet varied, this general pattern shows some interesting departures. In collaboration with Bonnie G. McEwan of the Florida Bureau of Archaeological Resource Management, we analyzed teeth from the San Luis mission site. Later work on the teeth by Tiffiny A. Tung, now of Vanderbilt University, indicated that people in this mission had fewer cavities than did their counterparts at other sites. This departure from the usual pattern

BRYAN CHRISTIE

THE AUTHOR

CLARK SPENCER LARSEN directs the La Florida Bioarchaeology Project, which involves the collaboration of many scientists from the U.S. and abroad. He began his studies of ancient human skeletons in his freshman year at Kansas State University, where he received his B.A. in 1974. His doctorate in biological anthropology was awarded by the University of Michigan at Ann Arbor in 1980. Larsen is distinguished professor of social and behavioral sciences and chair of the Ohio State University department of anthropology and a research associate with the American Museum of Natural History in New York City. He is currently editor in chief of the *American Journal of Physical Anthropology*.

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

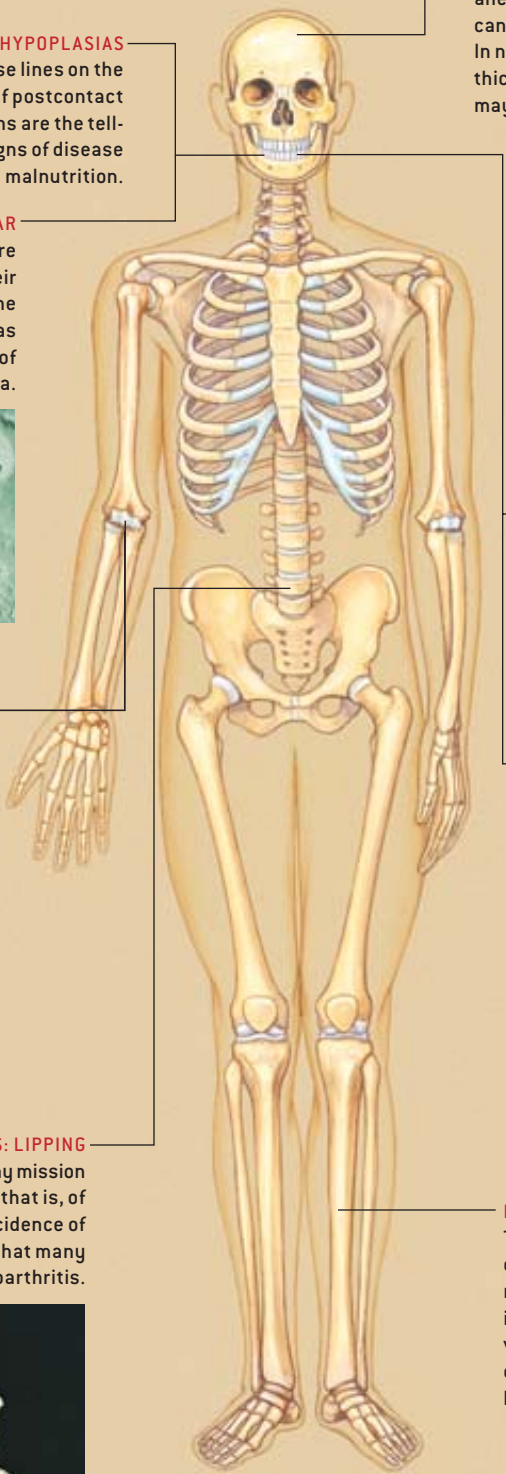
Signs of Stress in a Skeleton

HYPOPLASIAS
These lines on the teeth of postcontact Indians are the telltale signs of disease and malnutrition.

TOOTH MICROWEAR
The teeth of mission Indians are smoother (*left*) than those of their ancestors (*right*), suggesting that the later diet centered on soft foods, such as corn gruel, which promote the buildup of plaque and cavity-causing bacteria.

OSTEOARTHRITIS: JOINT POLISH
Excessive wear and tear on a skeleton can be detected in several places, including the joints. Polishing of the joints indicates that cartilage was worn down and that the joint surface had deteriorated.

OSTEOARTHRITIS: LIPPING
The vertebrae of the lower back in many mission Indians show evidence of lipping—that is, of distortion from heavy lifting. The incidence of lipping and the joint polish suggest that many adult workers suffered from osteoarthritis.



ANEMIA AND POROTIC HYPEROSTOSIS
Corn contains phytate, which inhibits the absorption of iron. As a result, many mission Indians suffered from anemia, and their bones have sievelike lesions that can be seen on the skull and in a microscopic close-up. In nonanemic individuals the dark bands would be much thicker than those shown here (*right*). (These lesions may also be the result of parasitic infection.)

DENTAL CAVITIES
Cavities were common in Indians who ate a lot of corn—a grain that contributes to tooth decay.

RETZIUS LINES
These growth lines can be seen in tooth enamel. In many of the mission Indians they are abnormally dark, indicating that poor diet and disease were common.

INFECTION
The lower leg bones, or tibiae and fibulae, of many of the Indians living in the missions have visible lesions. These can be caused by bacterial infections.

ROBERTO OSTI (*skeleton; dental cavities; anemia drawing; hypoplasias*); MARK TEAFORD (*tooth microwear*); BARRY STARK (*osteoarthritis; joint polish and osteoarthritis; lipping*); MARK C. GRIFFIN (*infection*); MICHAEL SCHULTZ (*anemia photograph*); SCOTT W. SIMPSON (*Retzius lines*)

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

may have been explained by the research of Elizabeth J. Reitz of the University of Georgia, who examined animal remains at the same site. She determined that people living in San Luis had access to beef—a rare addition to the mission Indians' standard diet—and that protein may have inhibited the formation of cavities.

The tooth record has provided us with other important insights as well. Hutchinson and I have found that many Indians had hypoplasias—visible lines on teeth caused by disease or malnutrition. The large size of the hypoplasias in some Indians suggests that they experienced severe or sustained illness or poor nutrition, or both. We also found evidence of disturbances in tooth development. With Scott W. Simpson of Case Western Reserve University, we studied microscopic features of teeth, looking at what are called Retzius lines—growth lines that can be seen in enamel. Although both precontact and mission Indians have abnormal Retzius lines, these malformations are more prevalent in the mission Indians.

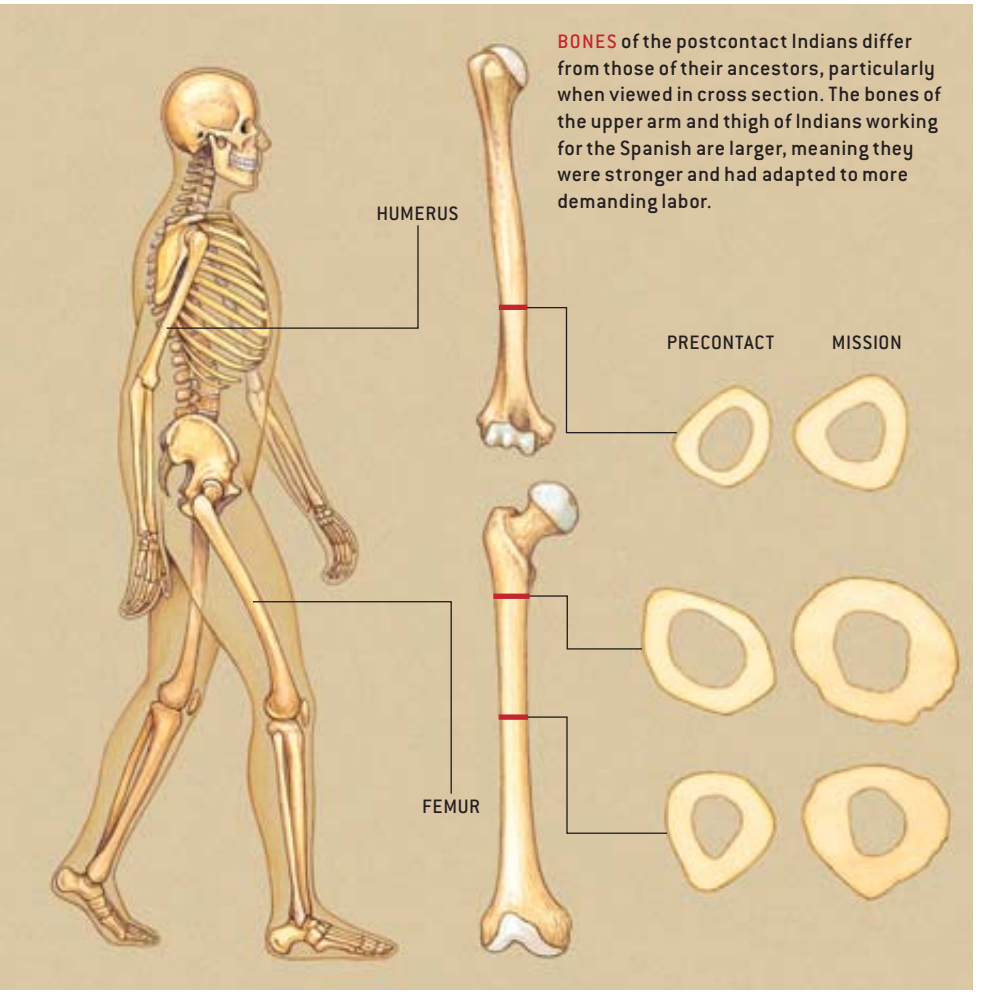
Considered together with other evidence, the increase in abnormal Retzius lines suggests that poor diet was not the only problem facing the mission Indians. David Hurst Thomas of the American Museum of Natural History in New York City has excavated a shallow, plank-lined well in Santa Catalina de Guale that may have served as a reservoir for parasites. Although their ancestors relied on freshwater streams and springs, the mission Indians drank well water, and anyone living in the region today knows the dangers of drinking water from shallow wells: it is easily contaminated and can cause parasitic infection and other problems.

The probability of rampant infection is strengthened by the fact that most of the defective tooth enamel we studied appears to have been formed during the first two years of life. This is a period when dehydration from infantile diarrhea is a primary health threat. Acute dehydration can inhibit the function of all forms of cells, including ameloblasts—the cells responsible for enamel formation. As in many underdeveloped nations today, bacteria and viruses in contaminated food and water cause infantile diarrhea. Certainly the mission would have created the kind of living circumstances that promote infantile diarrhea and the pattern of growth stress we have seen in teeth.

Other diseases, such as smallpox and measles, may have easily spread as well because the Indians were clustered together in crowded communities around the missions. Although many acute infectious diseases kill people long before their bones are affected, some infections—such as those caused by the bacterium *Staphylococcus aureus*—can travel from a soft-tissue wound to nearby bone, leaving observable lesions. Numerous lower-leg bones, or tibias, of contact-era Indians have lesions that suggest just this kind of infection.

Infection can also cause anemia because some types of parasites, such as hookworm, bleed their human hosts. Observations of mission bones indicate that such infection was common. The surfaces of many of these bones have sievelike lesions—called porotic hyperostosis—that can be caused by iron deficiency, scurvy or infection. Few precontact Indians seemed to have these lesions, probably because their diet of fish and maize together provided enough iron to stave off anemia. But the abundance of porotic hyperostosis in the mission Indians was most likely the result of the anemia brought on not simply by an increasingly corn-rich diet but also by intestinal infection.

Food and living conditions were not the only aspects of culture that were drastically altered for the Indians who lived in the missions. The Spanish practiced *repartimiento* draft labor in *La*



BONES of the postcontact Indians differ from those of their ancestors, particularly when viewed in cross section. The bones of the upper arm and thigh of Indians working for the Spanish are larger, meaning they were stronger and had adapted to more demanding labor.

ROBERTO OSTI

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.

AGRICULTURE among the mission Indians, such as the Timucua depicted in this 16th-century engraving, increased enormously after the Spanish arrived. The shift was not beneficial for the natives of *La Florida*. Agriculture ultimately forced them to simplify their diet to such a degree that their health suffered.

Florida, which meant that able-bodied Indian men were required to work on farms, in public works and government building projects, and for the military. Indians were also required to carry heavy loads over long distances, because draft animals were not available in the region until after 1680 or thereabouts. In our studies of skeletons, we noticed that contact-era Indians had a higher rate of osteoarthritis than their predecessors did—a phenomenon we believed had been caused by the increased workload, because wear and tear on the joints can lead to osteoarthritis. But the condition is related to other factors as well. So we decided to investigate further, looking to the skeletons for more answers.

Working Bones

THE SKELETON of a living person is highly responsive to physical activity. Throughout life a person's bones change shape and structure in response to mechanical forces acting on them. Basically, bone tissue is placed where the skeleton needs it. When a person walks, for example, or stands, forces deriving from the pull of muscles or from body weight trigger cellular activity in the bone that results in skeletal remodeling. Without the proper amount or distribution of bone in key places, the force of bending or twisting could break the thigh bone, or femur.

Drawing from methods developed by civil and mechanical engineers for measuring the strength of building materials, Christopher B. Ruff of the Johns Hopkins University School of Medicine and I have analyzed the strength of femur and humerus (upper arm) bones from both precontact and mission sites in *La Florida*. This approach entails measuring cross-sectional geometric properties of the bones called second moments of area. Second moments of area reflect how the bone is distributed in cross section and indicate the strength or ability of the bone to resist breaking during bending or twisting. The analysis entails tracing the profile of the outer (subperiosteal) and inner (endosteal) perimeters of the bones in cross section and then calculating the biomechanical properties of the bone [*see illustration on page 102*].

We discovered that the mission Indians had stronger bones than their predecessors did: the later bones had greater second moments of area than the earlier bones. This is not to say that the bones of the mission Indians were better than those of their ancestors. Rather the bones had just adapted to new mechanical demands. Given the well-known circumstance of exploitation and the heavy workloads of the Indians laboring under the Europeans, we believe that the increases in bone strength and osteoarthritis were caused by fundamental alterations in their way of life that involved increased physical activity.

The insights afforded us by bioarchaeology confirm much of what is found in historical texts—including the forced labor of the Indians and the diseases that plagued them—but they also give us a much more comprehensive and precise picture of the past. European contact introduced hardships on many fronts. Pestilence, poor nutrition, iron deficiency, growth disruption, infection and hard labor all took their toll. Yet despite the unfavorable state of affairs, native peoples accommodated new demands and new challenges, a story that is repeated time and again in the history of our species. SA

MORE TO EXPLORE

The Archaeology of Mission Santa Catalina de Guale, Vol. 1: **Search and Discovery.** David Hurst Thomas. Anthropological Papers of the American Museum of Natural History, Vol. 63, Part 2, pages 47–161; June 12, 1987.

The Archaeology of Mission Santa Catalina de Guale, Vol. 2: **Biocultural Interpretations of a Population in Transition.** Edited by Clark Spencer Larsen. Anthropological Papers of the American Museum of Natural History, No. 68; October 9, 1990.

In the Wake of Contact: Biological Responses to Conquest. Edited by Clark Spencer Larsen and George R. Milner. Wiley-Liss, 1994.

The Apalachee Indians and Mission San Luis. John H. Hahn and Bonnie G. McEwan. University Press of Florida, 1998.

Skeletons in Our Closet: Revealing Our Past through Bioarchaeology. Clark Spencer Larsen. Princeton University Press, 2000.

Bioarchaeology of Spanish Florida: The Impact of Colonialism. Edited by Clark Spencer Larsen. University of Florida, 2001.

FROM *BREVIS NARRATIO* (1591), BY JACQUES LE MOYNE

COPYRIGHT 2005 SCIENTIFIC AMERICAN, INC.